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A REPORT ON POLLUTION OF LAKE MICHIGAN IN THE VICINITY OF CHICAGO'S SOUTHERLY WATER INTAKES

PUBLIC HEALTH SERVICE, CHICAGO, ILLINOIS

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The average raw water contamination with which a water treatment process employing chlorination alone can usually produce a water meeting the Treasury Department Standard is generally 50 coliform organisms per 100 ml, providing a maximum pollution of 400 coliform organisms per 100 ml is not exceeded more than 5 percent of the time. The percentage of coliform bacteria and the frequency of occurrence of high degrees of pollution in Lake Michigan increased steadily from 1937 to 1941. A temporary increase in diversion or water from Lake Michigan via the Calumet River and Saginaw Channel was requested to carry away an increasing amount of pollution entering the lake.

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A REPORT ON

POLLUTION OF LAKE MICHIGAN

IN THE VICINITY OF

CHICAGO'S SOUTHERLY WATER INTAKES

BY

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U. S. PUBLIC HEALTH SERVICE DISTRICT No. 3
CHICAGO, ILL., JANUARY, 1942

REPORT MADE ON REQUEST OF
HERMAN N. BUNDESEN, M. D.---PRESIDENT CHICAGO BOARD OF HEALTH
TO
THE SURGEON GENERAL---U. S. PUBLIC HEALTH SERVICE

REPORT ON REQUEST
OF
PRESIDENT OF THE BOARD OF HEALTH
City of Chicago
To
SURGEON GENERAL
U. S. Public Health Service

For assistance in obtaining diversion of additional quantities of water from Lake Michigan, temporarily and until present emergency has passed.

Introduction

Complying with instructions from the Chief Engineer of the Sanitation Section, U. S. Public Health Service, that information be obtained regarding a practical course of procedure that might be helpful in protecting the safety of the Chicago water supply, the following report is submitted.

General Conditions

On December 27, Dr. Bundesen, President of the Chicago Board of Health, sent a telegram to the Surgeon General in which he quoted a telegram from Mayor Kelly to Secretary of War Stimson calling attention to the increase in pollution of Lake Michigan in the vicinity of the city's southern water works intakes, and requesting an adequate temporary increase in diversion of water from Lake Michigan via the Calumet River and Saginaw Channel, in order to carry away an increasing amount of pollution entering the lake from Indiana Harbor and other points. Dr. Bundesen requested assistance of the Public Health Service in avoiding what he considers a possible health menace.

Reasons for the Request

The pollution, measured in terms of the annual average number of coliform bacteria per 100 ml. present in the raw water at the Dunne Crib intake, the most southerly of the Chicago intakes, as

determined by the City Health Department's Laboratories, has increased steadily in recent years.

From summaries[1] prepared by the Water Purification Division, City of Chicago, covering the period 1927 to November 30, 1941, the following average values of the quality of the raw water obtained through the Dunne Crib during the last five years are obtained:

Year	Average No. of Coliform Bacteria per 100 ml. (Daily Samples)
1937	33
1938	52
1939	222
1940	238
1941	404

The frequency of occurrence of high degrees of pollution at these intakes, as reported by the Water Purification Division[2], has also increased in recent years. Thus the number of days when the number of coliform organisms was in excess of 240 per 100 ml. was 20, 27, 27.5, 36 and 52.5 for the years 1937, 38, 39, 40, and 41 (11 months) respectively. There were occasions during the last three years of this period when the pollution at this intake reached concentrations of 300,000 coliform organisms per 100 ml. for short times.

The average raw water contamination with which a water treatment process employing chlorination alone can usually produce a water meeting the Treasury Department Standard is generally assumed to be about 50 coliform organisms per 100 ml., provided a maximum pollution of 400 coliform organisms per 100 ml. is not exceeded more than 5% of the time.(1) By referring to Figure 3, it will be

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[1]See Fig. 1
[2]See Fig. 2
(1) Journal of the American Water Works Assn. Vol. 27, No. 9, p.1119.

noted that the raw water at Dunne Crib has frequently reached average values of pollution in excess of those considered to be safe; and during the years 1938, 39, 40, and 41, has been above such values and has been progressively getting worse.

Figure 4 shows that the annual average quality of the raw water of the South District of Chicago has been above the average limits believed to be safe for water which is treated with chlorine alone, a large part of the time since 1927.

This figure also indicates that the periods of excessive pollution coincide with periods of increased industrial activity. The figure shows too that during periods when much more water was diverted from Lake Michigan than is now allowed, the quality of the raw water at Dunne Crib was not satisfactory. Thus in 1930, when 8500 c.f.s. were diverted, the average number of coliform organisms per 100 ml. was a little over 200. During 1939 and 1940, when only 1500 c.f.s. were allowed, the raw water was about of the same quality as in 1930.

From these figures it is evident that the city authorities charged with the responsibility of providing citizens of Chicago with safe water have grounds for alarm. While it is true that the water obtained through the 68th Street and Dunne Cribs is chlorinated twice, once at the cribs and again at the pumping station, the margin of safety must nevertheless be considered to be narrow and to be growing narrower steadily.

Interruptions to the chlorination process occur. Thus in 1940 a boat dragged anchor and broke the power cable supplying power to Dunne Crib, putting the crib treatment plant out of commission for three weeks. During this time, the only protection

the water consumers had was the brief contact treatment afforded by the pumping station ashore. In cold weather, the treatment pumps supplying treatment for water at the crib are put out of commission for brief periods.

Confidence in the ability of the chlorination process alone to adequately deal with the degree of pollution encountered at the southern intakes is shaken still more as one studies the results of the examination of the finished water actually supplied to consumers daily. These samples are collected by the Water Purification Division, Department of Public Works, and examined in the City Health Department Laboratories. The results are shown in Figure 5. They show the presence of coliform organisms in concentrations in excess of those permitted in the Treasury Standards(2), for the various periods of time.

Three methods of collecting raw and treated water samples are employed in order to check the results obtained. They are the regular, sodium thiosulphate and direct plant methods. The regular method consists in drawing a sample of water into a sterile bottle for examination in the laboratory. The sodium thiosulphate method consists in drawing the sample into a sterile bottle into which has been introduced a small quantity of sodium thiosulphate before sterilization in order that any traces of free chlorine present in the water at the time it is sampled may be removed and the bactericidal action stopped.

(2) Public Health Reports, Vol. 40, April 10, 1925.

The removal of excess chlorine from the sample at the time it is collected by using sodium thiosulphate gives a picture of the quality of water a consumer located at the point of sampling would obtain while the regular method gives a picture of the quality at some point beyond the sampling station represented by the distance the water in the distribution system travels during the time the free chlorine or chloramines may continue their bactericidal action. The direct plant method may be considered to be a check on the sodium thiosulphate method.

The regular method is continued in use to permit comparisons with results obtained in previous years.

When one examines Figure 5, it becomes evident that there are periods of weeks and even months when the quality of the water at the points where the samples were collected failed to meet the Treasury Department Standards. This was the case in July, August, September and October, 1940 (see column 18) and in June, 1941.

Twice in the past has inadequately chlorinated water resulted in outbreaks of typhoid fever in the south districts of Chicago, supplied principally from the southern intakes. One occurred in 1916 when an outbreak in January and February resulted in 105 cases and 8 deaths, and another in 1923 in November and December, when there were 228 cases and 23 deaths. Both of these outbreaks occurred in cold weather, when the viability of typhoid organisms in drinking water is greatest.

Some of the largest typhoid fever outbreaks in the United States have been due to inadequate chlorination, when chlorination was the

only treatment. During the period 1920 to 1936, some 52 outbreaks of typhoid fever due to inadequate chlorination occurred in the United States.(1)

Water Treatment Processes

The water obtained from Lake Michigan by the City through its various intakes is treated with chlorine applied to the suction side of the pumps which pump the water into the distribution lines. This is the only barrier protecting water consumers from pollution in the raw water, except at the Dunne and 68th Street Cribs, where ammonia and chlorine are applied to the water in the tunnels leading from the lake intakes to the pumping stations located ashore. This treatment minimizes chlorophenol tastes which have arisen here in the past, apparently due to the presence of small quantities of certain industrial wastes, particularly wastes from by-product coke plants, oil refineries, etc. present in the water supply. The bactericidal action of this treatment is considerably slower than when chlorine alone is used. But since a contact period of an hour or more is afforded in the tunnel leading from the cribs to the inshore pumping stations, it has been considered feasible to utilize this treatment and thus minimize complaints due to tastes. Chloramine residuals can also be maintained in the distribution system over a longer time.

Thus far, "break point" chlorination has not been practiced, partly, it is stated, because of the limited capacity of the installed chlorinators. Consideration is being given to trying it, however, at the Dunne and 68th Street Cribs.

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(1) Journal of the American Water Works Assn. Vol. 31, No. 2, pp. 325-373.

The water obtained through the Dunne and 68th Street Cribs, the southerly-most of the water intakes maintained by the City of Chicago, is most seriously exposed to contamination from industrial wastes and sewerage entering Lake Michigan, principally from Indiana cities located in the vicinity of Chicago. The intakes are located practically side by side. About 85% of the water treated at these two stations enter through the Dunne Crib and 15% through the 68th Street Crib.

A BRIEF DESCRIPTION OF THE DUNNE CRIB AMMONIA-CHLORINE TREATMENT PLANT, CHICAGO WATER SUPPLY SYSTEM.

The Dunne Crib ammonia-chlorine treatment plant was placed in operation July 31, 1936. The plant is located on the Dunne Crib in Lake Michigan about two miles from shore. It treats all the water entering the 68th Street and Dunne intakes, averaging 360 m.g.d. - with peak periods at rates in excess of 500 m.g.d. - which is supplied to the entire south side of the city and in addition to 18 suburban communities - a total population of 1,400,000.

The plant was built because of the recognized necessity of fortifying chlorination control measures against the hazards of abnormal chlorine absorption caused by the presence of sewage and industrial waste in the lake water. The treatment was also for the purpose of giving much needed additional protection, especially in the critical period after December 31, 1938, when by the order of the U.S. Supreme Court the amount of water which the Sanitary District was allowed to divert from Lake Michigan was reduced from an annual average of 5,000 c.f.s. to 1,500 c.f.s.

Results of laboratory studies indicated a marked lag in bactericidal velocity of the ammonia-chlorine treatment, requiring a contact of at least 1-1/2 to 2 hours between the water and chemicals before satisfactory efficiencies are obtained. By applying the chemicals at the lake intakes, advantage is taken of the contact period, during the flow of water through the tunnels to the pumping stations, to overcome the objection of the lag in bactericidal velocity. Under average conditions the flow from the Dunne Crib to the 68th Street pumping station is about 1-1/2 hours and to the Roseland and Western Avenue Pumping stations about 7 hours. The chlorination equipment at the shore pumping stations is used to apply an additional dosage of chlorine to the water as a safety measure and also a standby to be used in case of interruption of chemical application at the intake plant.

When the Dunne Crib was built about 25 years ago, no consideration was given to the possibility of its being used as a water treatment plant. Space on this crib was decidedly limited. Therefore, in making the plant layout and in the selection of equipment, an unusual situation had to be met. In addition there were difficulties to be overcome due to the exposed location of the crib in the lake. Ample storage space for chemicals and other supplies was provided to permit uninterrupted operation during long periods in the winter, when contact with the crib might not be possible due to serious ice conditions and storms on the lake.

Floor space for storage was provided by placing 1/2" checkered steel flooring over the open well, providing a floor area of 2,000 square feet. Another 2,800 sq. ft. floor area was obtained by placing a reinforced concrete slab roof over the annular space between the well housing and the outer parapet wall of the crib. This space provided a chlorine storage room large enough to store 40 days supply, a chlorine evaporator room and a chlorine operating room.

Chlorine is purchased in ton containers and ammonium sulphate in 100-lb. paper-lined burlap bags. A special steel decked scow was built to transport chemicals and fuel to the crib. Its deck is fitted with steel saddles for 30 1-ton chlorine drums and cargo supports for 39 steel unit containers, each capable of holding 20 100-lb. bags of ammonium sulphate. There is a 11,000 gallon compartment in the hull of the scow for carrying fuel oil and electrically driven pumps for pumping this oil into the fuel oil tanks located on the 68th street crib. At the cribs the chemicals are unloaded from the scow by means of a 3-ton electric traveling hoist operated over a bridge crane. The ton containers on the Dunne Crib are handled by 2-ton electric monorail hoist..

A specially designed chlorine control equipment for high capacity is used for applying chlorine to the water. This consists of 3-3,350-lbs. per day capacity and 3-800-lbs. capacity Rotameters. International Filter Company dry chemical feeders are used to apply the ammonium sulphate to the water.

Electric power for operation of equipment is furnished through a submarine cable from shore, carrying 2300 volts to 4 transformers

located on the crib where the voltage is reduced to 230 and 115 volts for power and lighting circuits. Water supply for chlorine injectors and other purposes is furnished by duplicate 300 g.p.m. centrifugal pumps operated against a 165 ft. head. Duplicate Kewaunee boilers, oil-burners, fuel oil tanks and accessory equipment are installed on the adjacent 68th Street crib.

As protection in case of chlorine gas leakage, each room is provided with suction blowers and ducts discharging outside of the crib and capable of making an air change every minute. An additional protection is a steel tank containing sufficient caustic soda to absorb a ton of chlorine. The operating crew is quartered adjacent to the 68th Street crib where complete sleeping and eating accomodations are provided. Fecal matter from the operating personnel is incinerated on the crib. Liquid wastes are heavily chlorinated, and after being tested, are discharged overboard.

In order to maintain closer supervision over the treatment on the cribs, a control station is established on shore adjacent to the 68th Street pumping station. Here trained sanitary engineers are on duty at all hours of the day and night. A 15-wire submarine telephone cable is laid on the lake bottom from the control station to the crib. Over this system the engineer transmits orders to the operating staff on the crib regarding rate of feed of chemicals. The effectiveness of the treatment is checked by hourly residual chlorine tests by the control engineer. He also receives reports from the three south side pumping stations pertaining to the residual chlorine in the water reaching these stations.

Accurate information regarding the instantaneous rate of flow through the lake tunnel is provided by a 36-inch Sparling propeller type meter installed in each of the intake shafts in the Dunne Crib which indicates and records the flow into the intakes on instruments located in the crib chlorine operating room and by means of remote control in the control station on shore over the wires in submarine cable.

During 1940 an average chlorine dosage of 4.95 lbs. per m.g. and an average ammonium sulfate of 4.73 lbs. per m.g. was applied at the Dunne Crib treatment plant. The maximum chlorine dosage was at the rate of 14 lbs. per m.g. In addition to the crib treatment, an average of 1.8 lbs. per m.g. chlorine was applied at the shore pumping stations.

The capacity of the equipment now installed is reported to be approximately 15 lbs. per m.g.

Principal Sources of Pollution Affecting the Dunne St. and 68th St. Intakes

The principal sources of pollution of the south end of Lake Michigan and distances from Dunne intake crib is shown in Figure 6. From an investigation of the pollution of Lake Michigan in the vicinity of the Calumet and Indiana Harbors made jointly by the U.S.P.H.S. and the states of Illinois and Indiana and reported in Public Health Service Bulletin No. 170 in 1927, it is evident that much of the contamination reaching the southernmost Chicago intakes is interstate in origin, ...arising largely from industrial wastes and domestic

sewage discharged into Lake Michigan directly or through the Indiana Harbor Ship Canal or the Calumet River.

These studies, and those made subsequently by the Division of Water Purification, City of Chicago, show that pollution entering Lake Michigan at the mouth of the Indiana Harbor Ship Canal can reach the Dunne and 68th Street intakes in several hours. The direction and velocity of the wind strongly affects the direction and velocity of travel of the pollution. It has been found, in general, from studies made here, that floats travel from 3% to 7% as fast as the wind and in the general direction in which the wind blows. Wind directions and velocities in this area are shown in Figures 7, 8, 9, 10 and 11. The paths over which certain floats traveled, after having been released at various points in the Calumet area, are shown in figures, 12, 13, 14, 15, and 16.

The effect of this intermittent pollution upon the water treatment process is disconcerting and dangerous since the amount of pollution that must be dealt with may suddenly be greatly increased and the presence of certain industrial wastes may use up the chlorine needed for the bactericidal treatment of the water. At times, this pollution has increased to 300,000 coliform organisms per 100 ml. The amount of chlorine necessary to deal with the pollution may increase from an average of around 4 to 5 lbs. per m.g. to 12 to 14 lbs. per m.g. Should the chlorination process be interrupted during such periods or should an insufficient quantity be applied, the results might again easily result in disaster to many Chicago water consumers.

Indiana Harbor Ship Canal

The Indiana Harbor Ship Canal discharges a stream of mixed industrial wastes, cooling water and domestic sewage into the lake continuously. The volume varies principally with the quantity of cooling water used in the steel mills in the Calumet region. Measurements of this flow and of that in the Grand Calumet west of its junction with the Canal made by the Sanitary District are shown below:

DISCHARGE MEASUREMENTS
GRAND CALUMET RIVER
and
INDIANA HARBOR SHIP CANAL

	Indiana Harbor Canal C. F. S.	Grand Calumet West of Junction C. F. S.	Grand Calumet* East of Junction C. F. S.	Elev. Lake Mich. COD
May 4, 1928	a 380	b 140	520	+0.05
July 31, 1928	a 345	b 225	570	+0.45
Sept. 15, 1928		b 175		+0.45
June 15, 1929	a 385	c 270	655	+2.20
March 6, 1931	a 410	c 105	515	-0.85
July 9, 1931	a 420	c 120	540	-0.77
Sept. 6, 1932	a 320	c 30	d 350	-1.75
July 24, 1936	a 541	ee 93	634	-1.40
August 12, 1936	a 540	f 53	593	-1.50
October 18, 1939	a 515	f 86	601	-0.50
August 9, 1940	a 510	f 98	609	-0.30
August 8, 1941	a 635	f 60	695	-1.00
August 14, 1941	a 630	f 50	680	-1.20
Nov. 28, 1941	a 413	f 48	461	-0.90
Dec. 11, 1941	a 425	f 56	481	-1.00
Dec. 31, 1941	a 594	f 54	648	-0.80

*Flow - Sum of Indiana Harbor Canal and Grand Calumet west of junction.

a. Measured at 151 St. Street Bridge, East Chicago
b. Measured at P.C.C.R.R. Bridge, Burnham
c. Measured at Forsythe Avenue Bridge, East Chicago
d. Inland Steel Mills at Gary operating at about 25% capacity
e. Measured at Burnham Avenue, Calumet City
f. Measured at Hohman Avenue, Hammond.

According to recent data reported by the Water Purification Division, there were 300,000 + coliform organisms in 100 ml. of sample obtained at the mouth of the canal on October 2, 1941 and 3,000,000 + on October 8, 1941 (See figures 17 and 18). This pollution enters the lake only a little more than 9½ miles from Dunne Crib.

The Calumet River discharges, at times, into the Lake Michigan watershed and at times into the Mississippi watershed. Figure 19 shows the number of hours for each month of 1941 when the discharge was into Lake Michigan and shows that it discharged into the lake during every month of 1941 except February and during the whole year it discharged into the lake over a period of 2057 hours or 25.4% of the time. There was no flow during 3111 hours or 35.6% of the time. The river diverted water from the lake only during 3592 hours or 41.0% of the time.

It is contended that it is difficult to operate the system of rivers, channels, and canals that comprise the drainage system of the Chicago Sanitary District in such a way that the Calumet River will not discharge into Lake Michigan. This is due to the fact that when there is a heavy rainfall, the runoff may be sufficient to cause a flow towards the lake, or the water level in the lake itself may drop due to a seiche induced by changes in atmospheric pressure over the lake or to storms.

From figures supplied by the U. S. Lake Survey, for example, for November, 1941, a fluctuation in the lake level amounting to .52 feet occurred within an hour's time on November 1, and attained a maximum fluctuation in 16 hours of 1.1 feet. On November 25 a maximum variation in lake levels amounting to 1.42 feet occurred

within a period of 8 hours. The maximum fluctuation during the month amounted to 2.92 feet and occurred between the 6th and 25th of the month.

The fluctuation in the lake levels from 1927 to 1941 are shown in figure 20 and show a maximum fluctuation over this entire period of 8.5 feet. The highest elevation being recorded in 1930 and the lowest in 1940.

In Figure 21 are shown the principal channels of the Sanitary District of Chicago and the estimated average discharges carried in each channel in 1941. It will be noted from this figure that out of a total discharge at the Lockport controlling works of 3340 c.f.s., only 400 c.f.s. or about 12% were diverted from Lake Michigan through the Calumet River. During this period an effort was made to divert as much water as possible through the Calumet-Sag Channel and still maintain the main drainage channel in relatively good condition.

Hydraulics of the Sanitary District Channels

The operation of the drainage system of the Sanitary District may be said to be activated and dominated by four important factors. (1) To keep pollution out of Lake Michigan; (2) To maintain the various portions of the canals and rivers in good condition; (3) To operate the system in a manner which will permit the generation of a maximum amount of power, and (4) To maintain sufficient water in the channels so that navigation will not suffer, and that industries on the waterways can operate. All this must be done within the diversion limitations set by the Supreme Court in its decree of April 21, 1930.

The above decree enjoined the State of Illinois and the Sanitary District of Chicago from diverting water from the Great Lakes-St. Lawrence watershed in excess of the following annual averages, in addition to domestic pumpage.

From July 1, 1930 to December 31, 1935 . . . . 6,500 c.f.s.
From December 31, 1935 to December 31, 1938. . 5,000 c.f.s.
From December 31, 1938 . . . . . 1,500 c.f.s.

By referring to Figure 21—Channels of Sanitary District of Chicago--Approximate Discharges--, it will be noted that water is diverted from Lake Michigan at three principal ports. The Wilmette Pumping Station, Chicago River and Calumet River. Control works are located at Wilmette Harbor, at the mouth of Chicago River and at Blue Island on the Calumet - Sag Channel about 14 miles from the mouth of the Calumet River.

The water levels in the channels are controlled by operation of the power plant at Lockport, Illinois, and regulating dams located at that point. A head of 38 to 40 feet is available at this point for the generation of hydro-electric power and power worth approximately $1,500 per day is generated at this point.

The total diversion permitted includes the runoff from the streams tributary to Lake Michigan and the domestic pumpage, which in 1940 was approximately 1840 c.f.s.

The quantities of water diverted directly from Lake Michigan, and exclusive of runoff from tributaries of the Lake Michigan-St. Lawrence watershed in the Sanitary District, as estimated by the Sanitary District Engineers during periods when different diversion allowances were in effect are shown herewith:

	1931	1936	1941
Diversion Authorized by Supreme Court	6500	5000	1500
Direct diversion at Wilmette	295	178	110
" " " Chicago Harbor	4512	3266	236
" " " Calumet Harbor	1331	927	390
Percent of direct diversion taken at Calumet Harbor	21%	21%	59%

These figures show that during the past year a larger portion of the total direct diversion was taken at Calumet Harbor than was the case in 1931 or 1936.

Because 1941 was a wet year, the direct diversion at Calumet Harbor was smaller than for a year of average rainfall, 1941 was also a year of great industrial activity resulting in the accumulation of excessive pollution of the waters of the Calumet region including lower Lake Michigan.

The relative conditions of the waters in the Sag Channel and of those in the main drainage canal during 1941 is illustrated by the fact that at Summit on the main drainage canal some 10 miles above its junction with the Calumet-Sag Channel, the Dissolved Oxygen was "0" most of the time and the B.O.D. was approximately 40 p.p.m. Whereas, at Blue Island on the Calumet-Sag Channel, the Dissolved Oxygen was 3.3 in July, 1941 and the B.O.D. 4 p.p.m. In the vicinity of Lockport and Brandon Road pool, the Dissolved Oxygen was "0" a large part of the year.

SEWAGE TREATMENT IN THE CALUMET REGION OF INDIANA

A new activated sludge sewage treatment plant was placed in operation at Gary, Indiana on August 23, 1940. It treats the sewage from approximately 88,000 persons amounting to 17 to 18 m.g.d.

A smiliar plant was put into operation at Hammond, Indiana on August 20, 1940 treating the sewage from approximately 60,000 people. Approximately 1 m.g.d. of industrial wastes are still discharged into the lake. It is expected that this will be removed by February 1, 1942.

The sewage from the following towns is still untreated:

	1940 Pop.	Estimated Pop. Served by Sewers.
Whiting	10,307	10,500
East Gary	3,401	2,000
East Chicago	54,637	51,000
Calumet City	13,241	11,900
Calumet Park	1,593	1,400

A plant for East Chicago is under construction.

History of Litigation

According to the Report[1] of Special Master, Monte N. Lehman, to the Supreme Court of the United States dated March 31, 1941, the following is a brief history of the litigation.

"On May 9, 1922, the original proceeding in this cause was begun when the State of Wisconsin moved for leave to file for an injunction to prevent the State of Illinois and the Sanitary District of Chicago from diverting water from Lake Michigan at Chicago. The States of Minnesota, Ohio, Pennsylvania, Michigan and New York subsequently joined as complainants or filed independent bills. After a reference to Charles Evans Hughes, Esq., as Special Master, the Court on January 14, 1929, rendered an elaborate opinion through Chief Justice Taft (278 U.S. 367), holding the diversion of water from Lake Michigan to be illegal, except insofar as it might be required to maintain navigation in the Chicago River.

[1] In the Supreme Court of the United States No's. 2, 3 and 4. October Term, 1940.

"The case was again referred to Special Master Hughes for a report upon the practical measures necessary for the disposition of the sewage of the Sanitary District through other means than the diversion of water from Lake Michigan, the time which would be required therefor, what reduction in diversion would meanwhile be practicable, and the diversion which would be permanently necessary to maintain navigation in the Chicago River.

"On April 21, 1940, following the report of the Master upon this reference, a decree was entered pursuant to an opinion of Mr. Justice Holmes (281 U.S. 696), enjoining the State of Illinois and the Sanitary District of Chicago from Diverting any of the waters of the Great Lakes-St. Lawrence System or watershed through the Chicago Drainage Canal or otherwise in excess of the following annual averages, in addition to domestic pumpage:

From July 1, 1930 to December 31, 1935 . . . . 6,500 c.f.s.[2]
From December 31, 1935 to December 31, 1938... 5,000 c.f.s.
From December 31, 1938 . . . . . 1,500 c.f.s.

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[2](See next page)

"On October 10, 1932 (287 U.S. 568) upon the application of the complainants, Illinois and the Sanitary District were ordered to show cause why they had not taken appropriate steps to effect compliance with the requirements of the decree of April 21, 1930. After a reference to Edward F. McClennen, Esq., as Special Master, the Court, through Mr. Chief Justice Hughes, handed down an opinion enlarging its original decree by directing the State of Illinois to take all necessary steps, including the provision of necessary moneys, to secure the completion of adequate sewage disposal plants, together with any necessary controlling works to prevent reversals of the Chicago River (289 U.S. 395).

"On January 11, 1940, Illinois applied for a modification of the decree entered on April 21, 1930, to permit a temporary increase of the diversion to 5,000 cubic feet per second, in addition to domestic pumpage, until December 31, 1942. After a hearing upon this application, the Court on April 30, 1940, rendered a per curiam opinion (309 U.S. 569), in which it said:

> 'The State of Illinois has failed to show that it has provided all possible means at its command for the completion of the sewage treatment system as required by the decree as specifically enlarged in 1933 (289 U.S. 395, 710). No adequate excuse has been presented for the delay. Nor has the State submitted appropriate proof that the conditions complained of constitute a menace to the health of the inhabitants of the complaining communities or that the State is not able to provide suitable measures to remedy or ameliorate the alleged conditions without an increase in the diversion of water from Lake Michigan in violation of the rights of the complainant States as adjudged by this Court.
>
> 'In order, however, that the court may be satisfied as to the actual condition of the Illinois Waterway by reason of the introduction of untreated sewage, and as to the actual effect, if any, of that condition upon the health of the inhabitants of the

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[2] C.f.s. will be used in this report as an abbreviation for cubic feet per second. One cubic foot per second is approximately two-thirds of a million gallons per day.

complaining communities, and also with respect to the feasibility of remedial or ameliorating measures available to the State of Illinois without an increase in the diversion of water from Lake Michigan, the Court appoints a Special Master to make a summary inquiry as to such condition, effect and measures, and to report to this court with all convenient speed.'"

The net result of the hearings held by Special Master Lehman was to the effect that the conditions prevailing along the waterway, particularly at Joliet and in the vicinity of Brandon Road pool, were not a menace to the health of people or communities in the vicinity. He therefore recommended that the petition of Illinois for permission to divert 5000 c.f.s. be dismissed.

It is of interest to note, however, that during the course of the hearings and at the suggestion of the Special Master, the Supreme Court on November 25, 1940, entered a special order permitting a flow of 10,000 c.f.s. for 10 days beginning December 2 in order to permit an experimental flushing of the waterway.

It appears that this experimental flushing was arranged for by the Special Master in the course of a relatively short time. At his suggestion, counsel for the opposing states stipulated that the Court might enter such an order upon the understanding that their position in the case would not be in any manner prejudiced by the agreement. He also ascertained from the Chief of Engineers that the War Department would offer no objection from the standpoint of navigation.

The experimental flushing did not accomplish the improvements the experts expected of it and the Special Master commented, "The result seems to indicate the degree of uncertainty which must attend all expert opinion, even where it is in accord."

In the decree of April 21, 1930[1] it is stated:

"3. That on and after December 31, 1938, unless good cause be shown to the contrary, the defendants, the State of Illinois and the Sanitary District of Chicago, their employees and agents, and all persons assuming to act under the authority of either of them, be and they hereby are enjoined from diverting any of the waters of the Great Lakes-St. Lawrence system or watershed through the Chicago Drainage Canal and its auxiliary channels or otherwise in excess of the annual average of 1,500 cubic feet per second in addition to domestic pumpage."

The Court also retains jurisdiction as appears from Paragraph 7 of the decree.

"7. That any of the parties hereto, complainants or defendants, may, irrespective of the filing of the above-described reports, apply at the foot of this decree for any other or further action or relief, and this Court retains jurisdiction of the above-entitled suits for the purpose of any order or direction, or modification of this decree, or any supplemental decree, which it may deem at any time to be proper in relation to the subject matter in controversy.

"AND IT IS FURTHER ORDERED, that the costs in these cases shall be taxable against the defendants."

---

[1]Supreme Court of the United States. Nos. 7, 11 and 12, Original. October Term, 1929 (April 14, 1930.)

Discussion

From the evidence obtained from a study of the quality of the raw water at Dunne Crib, it is evident that there are frequent periods when there is more pollution in the raw water than can safely be taken care of when chlorination only is employed, measured by generally accepted standards.

This conclusion is strengthened when the quality of the water supplied to consumers is examined. There is evidence that for significant periods of time, the finished water fails to meet the Treasury Standards for water for use on interstate carriers.

The occurrence of two outbreaks of typhoid fever in the past among consumers supplied principally with chlorinated water from Dunne and 68th Street cribs and the recent sharp increase of pollution at these southern intakes is, in our opinion, ample reason for employing any remedial measures which will most promptly remove the threatened danger.

The fact that accidents have interrupted the chlorine-ammonia treatment plant on Dunne Crib for weeks at a time, notably in 1940, give additional cause for alarm and emphasize the need for protecting the quality of water at this intake to the greatest extent that may be practicable.

The most effective steps that can be taken to protect the southern water intakes consist in keeping contamination out of the lake. Sewage treatment facilities for all of the Calumet region should be provided as soon as possible.

Reversals of flow of the heavily polluted Calumet River into the lake at a point 3-3/4 miles from the 68th Street and Dunne intakes

contribute serious pollution to Chicago's water supply. The accumulation in the southern area of the lake of sewage and industrial waste pollution discharged from the communities and industries in the Calumet area is a constant threat to the quality of Chicago's water supply, since currents induced by winds or changes in lake level may carry this pollution to the Dunne Crib intakes. Formerly when greater diversion was permitted, some of this pollution may have been drawn into the Calumet River and finally into the Drainage Canal. The extent to which this may have occurred has not been ascertained as far as we have been able to learn.

Theoretically and actually, it would be possible to divert all of the 1,500 c.f.s. except a portion of the runoff through the Calumet-Sag channel. This would, in all probability, however, result in creating putrefactive conditions in the main drainage canal above its junction with the Calumet-Sag channel and would probably result in a storm of protests from persons living near or crossing the channel and from industries located near its banks and from those industries using these waters for industrial purposes.

It is argued that a considerable portion of the contamination entering southern Lake Michigan at various points between Burns ditch east of Gary and the Calumet River can be removed by diverting reasonable quantities of lake water through the Calumet-Sag channel.

It seems probable that large quantities of polluted lake water could be removed in this manner, particularly when the winds are from a direction tending to blow the field of contaminated lake water

towards the western shores of the lake. Any contamination thus removed would be that much protection to the Dunne Crib intakes.

There seems to be no certain way of knowing in advance how much diversion would be necessary nor precisely what would be accomplished by additional diversion. It is certain, however, that authorization of total diversions through the Calumet-Sag channel in excess of its carrying capacity are not warranted, since it is only the water diverted from the lake through the Calumet channel that is effective in protecting the southern intakes as long as flow into the lake at the mouth of the Chicago river is prevented.

An additional temporary expedient for protecting the intakes would be to construct a temporary dam across the inshore end of the Indiana Harbor Ship Canal near its junction with the Grand Calumet River, and diverting sufficient additional water through the Calumet River to prevent reversals of flow into the lake. This would not interfere with navigation since the Grand Calumet is not improved at this point. It might necessitate removing accumulations of mud and silt to keep them from being washed into the improved portions of the Little Calumet. It would keep the highly contaminated mixture of cooling water, industrial wastes and domestic sewage out of Lake Michigan.

This would not require large quantities of critical war materials and could probably be completed in a relatively short time. In a recent hearing in the Office of Production Management on the request of the Sanitary District for priorities on materials needed to complete construction of certain sewage works, it was indicated that O.P.M. would

rather see additional water diverted from Lake Michigan than release critical materials.

If this expedient is adopted, sufficient water should be diverted through the Calumet-Sag Channel to prevent a lakeward flow in the Calumet River, otherwise more harm than good would be done since the contaminated mixture above referred to would enter the lake much closer to the southern Chicago intakes than it now does.

Little additional diversion would be necessary if there were a lock on the Calumet River north of its junction with the Grand Calumet. Contamination of Lake Michigan coming from the Calumet Area could then be definitely prevented. In the absence of such a lock, it appears probable that additional quantities of diversion water may be required over those now authorized.

While it is not known precisely how much additional water would be needed for this purpose, it has been estimated at approximately 300 c.f.s. This, added to the cooling water pumped from the lake in the Calumet region, amounting to say 600 c.f.s., plus runoff from the Grand Calumet diverted out of the watershed and amounting to perhaps 100 c.f.s., would call for total additional annual diversion of about 1000 c.f.s.

This quantity could be reduced if the industries now pumping cooling water to the Grand Calumet River would return it, or most of it, to Lake Michigan. It is believed that voluntary cooperation of the industries to achieve this could be attained.

Conclusions

The existence of the present crisis in the water supply situation can be said to be due in an overwhelming measure to the sudden recent expansion of industrial effort necessary to meet the national emergency. While it may be true that Chicago has been slow to take steps to provide a water filtration plant for the supply taken from the southernmost intakes, it nevertheless has such a plant under construction. Its completion would probably require more than a year assuming that the necessary critical war materials, especially copper and steel, could be obtained.

In like manner, much of the pollution still entering the lake from the Calumet region is in process of being removed by the completion of sewage treatment plants, but is also contingent on ability to obtain critical war materials.

The expanded industrial effort in the Calumet region has greatly increased pollution in the lake, principally through the discharge of increased quantities of industrial wastes, including cooling water and domestic sewage. Large quantities of these wastes enter the lake through the Indiana Harbor Ship Canal and from there are carried by currents frequently induced by winds to the Dunne and 68th Street intakes.

Reversals of flow in the Calumet River have occurred more frequently in recent years than formerly, thus still further increasing pollution of the lake. These reversals are largely due to decreased diversion from Lake Michigan.

Remedial efforts can be divided into immediate temporary measures and subsequent permanent measures.

The most readily available temporary measure consists in diverting such quantities of lake water as may, by controlled experiment, be found to be sufficient to remove accumulations of polluted water in that portion of the lake lying roughly southwesterly of a line extending from Gary Canal to Dunne Crib and sufficient to prevent reversals of flow of the Calumet River. This measure would probably also improve the quality of the raw water available to the water filtration plants at Hammond, Whiting and East Chicago. It is believed that an additional 1,000 c.f.s. might be sufficient for these purposes.

It is probably not advisable to greatly reduce the amount of water diverted through the main drainage canal over the quantities passed through it in 1941 because of the demoralizing effect on persons and because of probable reductions in property values that might result should large portions of the main drainage canal in the built-up sections of the metropolitan area become putrefactive for lack of sufficient dilution water.

An additional temporary measure would be the construction of a temporary dam across the lower and unimproved portion of the Indiana Harbor Ship Canal near its junction with the Grand Calumet River. This would probably necessitate the dredging of portions of the lower end of the Grand Calumet to prevent the silting up of the improved portion of the Little Calumet. Along with this measure, steps should be taken to ascertain whether a portion of the cooling water used by industrial concerns at Gary could be returned to the lake.

As soon as the national emergency has passed, a resumption of the program of permanent improvements such as the completion of the water filtration plants for the entire city of Chicago, the completion of sewage treatment plants in the Calumet regions, and the completion of the sewage treatment plants for the Sanitary District of Chicago should be resumed. This report, however, is not intended to deal with the long term permanent improvement program but merely with measures for dealing with the present emergency.

RECAPITULATION

Summarizing the factual data above presented, the existing hazard to the safety of the Chicago water supply appears to be conclusively demonstrated through results of previous studies of the Public Health Service and supported by more recent data accumulated by the Chicago health authorities. To alleviate this situation pending the completion of adequate water filtration facilities, certain remedial measures of a more or less temporary nature are indicated as being beneficial. Such measures include: -

1. The diversion of additional quantities of water from Lake Michigan through the Calumet-Sag channel as a temporary expedient during the present emergency in an effort to reduce the pollution at the Dunne and 68th Street cribs to a point at which it will be possible with a reasonable margin of safety to provide water consumers with safe drinking water at all times. Such additional quantities of diversion water need be authorized only until the present national emergency has passed and the water filtration plant for the south side of Chicago can be completed. In as much as the Supreme Court of the United States has retained jurisdiction over the diversion of water of the Great Lakes-St. Lawrence watershed at Chicago, it would be advisable to explore the possibility of

obtaining permission during the present emergency to permit the diversion of an annual average of approximately 1,500 c.f.s. through the Calumet-Sag channel in addition to the diversions at present authorized, or as much thereof as may be necessary, to protect the water works intakes in southern Lake Michigan from the increased contamination now entering those waters, principally by reason of the expanded industrial activities due to the national emergency.

2. Budgeting of the quantity of water diverted through the Calumet River throughout the year so as to withdraw maximum quantities when wind-induced currents in the Lake are in the direction of Calumet Harbor and smaller quantities when such currents are away from the mouth of the Calumet River.

3. The construction of a temporary dam across the southern end of the Indiana Harbor Ship Canal north of its junction with the Grand Calumet River to prevent large quantities of industrial waste waters from transporting pollution into the Lake. Dredging of the Grand Calumet River may be necessary should this temporary dam be constructed. Such dredging would also benefit navigation.

4. Cooperation of industries in the Calumet area in providing the return of cooling water to Lake Michigan directly. This would reduce to a minimum the quantity of diversion water required.

5. Temporary expedients should not be considered a substitute for the provision of more adequate and permanent measures for providing a safe water supply for the City of Chicago. The completion of the water filtration plant now under construction should not be delayed.

FIGURE 1: Summary of Raw Water Quality Dunne Crib Intake, 1927 - 1941

FIGURE 2: Frequency of Occurrence of Coliform Organisms in Raw Water at the Dunne Crib Intake, 1925 - 1941

FIGURE 3: Summary of Coliform in Dunne Crib Raw Water Supply, showing how Water Meets Streeter's Limitations of Raw Water Quality for Chlorination Treatment of Great Lakes Waters, 1925 - 1941

FIGURE 4: Chart Showing Quality of Raw Water Supply of South District of Chicago, 1927 - 1941

FIGURE 5: Quality of Raw and Treated Water at 68th St. and Dunne Cribs, October 1939 - 1941

FIGURE 6: Major Sources of Pollution of Southern End of Lake Michigan with Distances from Dunne Intake Crib. Chicago Water Works System.

FIGURE 7: Navy Pier Wind Rose. 1927 - 1936

FIGURE 8: Navy Pier Wind Rose. Average Spring Season, 1927 - 1936

FIGURE 9: Navy Pier Wind Rose. Average Summer Season, 1927 - 1936

FIGURE 10: Navy Pier Wind Rose. Average Fall Season, 1927 - 1936

FIGURE 11: Navy Pier Wind Rose. Average Winter Season, 1927 - 1936

FIGURE 12: Lake Current Survey October 21, 1926-Lake Michigan near Calumet River.

FIGURE 13: Lake Current Survey June 17, 1927-Lake Michigan near Calumet River.

FIGURE 14: Lake Current Survey June 21, 1927-Lake Michigan near Calumet River.

FIGURE 15: Lake Current Survey June 28, 1927-Lake Michigan near Calumet River.

FIGURE 16: Lake Current Survey June 29, 1927-Lake Michigan near Calumet River.

FIGURE 17: Lake Survey October 2, 1941

FIGURE 18: Lake Survey October 8, 1941

FIGURE 19: Summary of Calumet River Flow, 1941.

FIGURE 20: Lake Michigan Fluctuation Recorded at NavyPier, 1927-1942.,

FIGURE 21: Channels of Sanitary District of Chicago, Approximate Discharges.

FIG. 1

SUMMARY OF RAW WATER QUALITY

DUNNE CRIB INTAKE

1927 - 1941

YEAR	AVERAGE COLIFORM BACTERIA PER 100ML.												
	JAN.	FEB.	MAR.	APR.	MAY.	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AVG. DAILY SAMPLES
1927 68 R-3	1.9	2.9	2.0	10.5	7.0	115.0	108.7	12.3	4.8	28.0	4.3	3.4	25.07
1928 68R-3	11.5	2.0	1.6	9.4	11.7	120.7	98.3	20.2	67.0	109.4	143.1	2.3	132.51
1929 68R-3	2.0	0.5	29.9	92.6	27.0	173.5	76.1	23.5	105.7	175.8	35.9	423.9	99.7
1930 * WESTERN R-1 68 R-3	* 50.4	* 10.8	97.1	2.0	59 2	7.0	133.9	57.3	1305.9	412.2	376.6	100.8	244.1
1931 68 R-3	11.6	3.3	28.0	29.7	14.5	39.0	7.7	26.5	2852	112.5	56.3	8.0	51.8
1932 68R-3	35.9	3.8	105.4	3.0	6.0	11.9	16.1	17.8	121.5	43.2	30.9	166.7	41.5
1933 68R-3	30.9	14.7	2.7	2.5	31.5	12.0	5.3	11.1	22.2	57.5	98.3	15.7	26.0
1934 ROSELAND R-1	23.7	9.1	8.7	0.7	129.5	35.7	39.2	24.5	51.8	113.8	109.8	50.6	48.9
1935 ROSELAND R-1	6.9	121.5	5.7	106.5	97.9	47.4	12.2	123.3	140.6	194.7	60.4	17.5	77.40
1936 * CRIB WELL ROSELAND R-1	35.1	2.6	0.6	1.8	14.8	20.8	10.5	* 106.1	* 4-25	* 324.0	* 12.7	* 3.1	111.5
1937 CRIB WELL	2 8	3.5	2.3	12.8	21.4	33.6	66.1	30.1	96.8	64.2	56.1	3.9	32.9
1938 CRIB WELL	7.7	10.9	25.4	3.8	9.8	53.5	34.5	147.3	198.7	99.3	13.9	8.1	51.9
1939 CRIB WELL	4 8	8.4	1.7	1007.8	54.4	117.0	726.9	287.0	210.9	(1) 181.4	18.1	6.9	221.5
1940 CRIB WELL	25.7	33.5	2.8	(4) 2.0	(4) 13.1	673.6	706.1	147.8	177.6	(5315.9) 4045	(2) 33.5	65.5	(653.0) 201.8
1941 CRIB WELL	57.2	11.3	15.2	3.7	152.6	846.8	(5585.5) (3) 646.8	771.0	424.2	619.7	200.1	61.7	(840.2) 404.8)
1942 CRIB WELL													
1943													
1944													
1945													

(1) Sample collected Oct 30 at 8 PM which showed 300,000 coliform per 100 ML. Not included in average.

(2) With 300,000 coliform sample at 7.30 AM. 10-19-40.

(3) With 300,000 coliform sample at 8.00 PM. 7-29-41.

(4) Partial month.

Water Purification Division, City of Chicago.

FREQUENCY OF OCCURRENCE OF COLIFORM ORGANISMS IN RAW WATER AT THE DUNNE CRIB INTAKE
1925 - 1941

YEAR	NUMBER OF SAMPLING DAYS	FREQUENCY OF OCCURRENCE BY DAYS, COLIFORM ORGANISMS PER 100 ml. (CALCULATED BY McCRADY'S TABLES)										ANNUAL AVERAGE COLIFORM ORGANISMS PER 100 ml. (McCRADY)
		0/5 10 ml.	1/5 10 ml.	2/5 10 ml.	3/5 10 ml.	4/5 10 ml.	5/5 10 ml.	1 ml.	.1 ml.	.01 ml.	.001 ml.	
		0	2	5	9	15	38	240	2400	30,000	300,000	
1925	356	223	66	26	12	8	6	14	1	0		18.2
1926	362	175	65	32	26	32	16	12	3	1		115.3
1927	360	181	63	44	26	23	8	13	2	0		25.07
1928	362	129	73	44	33	29	25	23	5	1		132.51
1929	358	111	64	46	32	34	30	30	11	0		99.7
1930	357	83	57	43	36	32	41	49	15	1		244.1
1931	364	86	68	37	40	50	54	25	4	0		51.8
1932	346	69	60	57	53	38	48	18	3	0		41.5
1933	354	74	65	61	53	41	41	18	1	0		26.0
1934	352	62	44	43	48	64	62	26	3	0		48.9
1935	365	44	59	54	54	46	67	34	7	0		77.40
1936	358	93	61	34	34	42	50	30	10	0		111.5
1937	361	128	58	47	28	42	36	20	2	0		32.9
1938	357	94	52	52	45	40	43	27	4	0		51.9
1939	359	80.5	61.0	40.0	41.5	45.0	52.5	27.5	10.5	1.5		221.5
1940	332.5	70.5	52.5	41.0	37.5	35.0	46.0	36.0	12.0	1.5	0.5	*653.0 201.8
1941	356	37	49	440	43.5	36.5	66.5	54.0	22.5	25	0.5	*840.2 404.8

Fig 2

* Including a 300,000 sample.

J.T.

Water Purification Division

SUMMARY OF COLIFORM IN DUNNE CRIB RAW WATER SUPPLY
SHOWING HOW
WATER MEETS STREETER'S LIMITATIONS* OF RAW WATER QUALITY
FOR CHLORINATION TREATMENT OF GREAT LAKES WATERS
1925 - 1941

YEAR	FREQUENCY OF OCCURRENCE BY DAYS, COLIFORM ORGANISMS PER 100 ml. (CALCULATED BY McCRADY'S TABLES)					ANNUAL AVERAGE COLIFORM ORGANISMS PER 100 ml.	PERIOD OF YEAR WHEN RAW WATER POLLUTION EXCEEDED STREETER'S MAXIMUM OF 50 COLIFORMS PER 100 ml		PERIOD OF YEAR WHEN RAW WATER POLLUTION EXCEEDED 400 COLIFORMS PER 100 ml. MAXIMUM ALLOWED BY STREETER'S STANDARD: 5 PERCENT	
	38	240	2400	30,000	300,000		NO. of DAYS	% of YEAR	NO of DAYS	% of YEAR
1925	6	14	1	0		18.2	20	5.5	12	3.3
1926	16	12	3	1		115.3	29	8.0	13	3.6
1927	8	13	2	0		25.07	22	6.0	12	3.3
1928	25	23	5	1		132.31	50	13.7	24	6.6
1929	30	30	11	0		99.7	66	18.1	34	9.3
1930	41	49	15	1		244.1	100	27.4	54	14.8
1931	54	25	4	0		51.8	80	21.9	24	6.6
1932	48	18	3	0		41.5	61	16.7	17	4.7
1933	41	18	1	0		26.0	54	14.8	15	4.1
1934	62	26	3	0		48.9	82	22.5	23	6.3
1935	67	34	7	0		77.40	98	26.9	34	9.3
1936	50	30	10	0		111.5	82	22.4	34	9.3
1937	36	20	2	0		32.9	52	14.3	18	4.9
1938	43	27	4	0		51.9	68	18.6	25	6.9
1939	52.5	27.5	10.5	1.5		221.5	84	23.0	33	9.1
1940	46	36	12	1.5	0.5	† 653.0 201.8	88	24.0	38	10.4
1941	66.5	54	22.5	2.5	0.5	* 840.2 408.8	124	34.4	61	16.1
1942										
1943										
1944										

Note:- * H.W. Streeter "Limiting standards of bacterial quality for sources of purified water samples" Jr. A.W.W.A. Vol. 27 No. 9 page 1117. Standard provides that for chlorination treatment alone, limiting safe degree of pollution as indicated by the mean coliform index is 50 per 100 ml. or a figure sufficiently lower so that the pollution shall not exceed 400 per ml. for more than 5 percent of the time assuming that the treated effluent were to meet with requirements of the U.S. Public Health Service drinking water standard

† Including a 300,000 sample

Fig. 3

Water Purification Division

CHART SHOWING QUALITY OF RAW WATER SUPPLY OF SOUTH DISTRICT OF CHICAGO

-1927-1941-

(1941 data includes only the first eleven months.)

——— CURVE OF HIGHEST MONTHLY AVERAGE DURING YEAR.

– – – CURVE OF ANNUAL AVERAGE FOR THE YEAR.

COLIFORM BACTERIA PER 100 ML.

1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
50
0

-NOTE-

Data excludes certain individual samples showing in excess of 300,000 coliform per 100 ML. If these figures are included, averages would increase as follows:

† 1940 Highest Monthly Average---from 706.1 to 5315.9
†† 1940 Annual Average ---------from 201.8 to 653.0
* 1941 Highest Monthly Average-from 1,424.2 to 5,585.5
** 1941 Average ----------from 404.2 to 840.2

ECONOMIC DEPRESSION 1931-1938.
Industrial activity in Calumet Region greatly curtailed.

Limits for chlorination only

1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941

DIVERSION FROM LAKE MICHIGAN PERMITTED THE SANITARY DISTRICT.

8,500 Cu. Ft. Per Sec.	6,500 Cu. Ft. Per Sec.	5,000 Cu. Ft. Per Sec.	1,500 Cu. Ft. Per Sec.

DIVISION OF WATER PURIFICATION

Fig 4

CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

WATER PURIFICATION DIVISION

SUBJECT _____

DATA _____ PAGE _____ OF _____

COMPUTED _____ CHECKED _____ D. CHECKED _____ DATE _____

Fig 5

YEAR	MONTH	68th St. Crib Raw Sample	68 K-2 Reg	68 K-2 Th10	68 K-2 D.P. Floc.	68 K-2 D.P. Effluent	68 T-4 Reg	68 T-4 Th10	68 T-4 D.P. Floc.	68 T-4 D.P. Effluent	Dunne Crib Raw Sample	Dunne 68 K-4 Reg	68 K-4 Th10	68 K-4 D.P. Floc.	68 K-4 D.P. Supernatant	68 K-4 D.P. Effluent	Dunne 68 T-1 Reg	68 T-1 Th10	68 T-1 D.P. Floc.	68 T-1 D.P. Effluent
Column		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1939	October	731.1	0.13	0.00	0.00	—	0.00	0.00	0.00	—	77.6	0.00	0.13	0.00	—	—	0.00	0.13	0.00	—
	November	29.7	0.10	0.10	0.00	—	0.00	0.00	0.00	—	79.7	0.10	0.00	0.33	—	—	0.00	0.00	0.00	—
	December	20.1	0.00	0.00	0.00	—	0.00	0.00	0.10	—	5.1	0.00	0.00	0.10	—	—	0.00	0.00	0.35	—
1940	January	9.4	0.00	0.00	0.00	—	0.00	0.00	0.00	—	6.1	0.00	0.00	0.09	—	—	0.00	0.00	0.00	—
	February	19.7	0.00	0.11	0.00	—	0.00	0.00	0.11	—	44.4	0.00	0.11	0.11	—	—	0.00	0.00	0.56	—
	March	93.6	0.11	0.30	0.40	—	0.00	0.30	0.60	—	3.9	0.00	0.00	0.40	—	—	0.00	0.11	0.90	—
	April	8.1	0.00	0.00	0.00	—	0.00	0.00	0.00	—	1.9	0.00	0.00	0.00	—	—	0.00	0.00	0.01	—
	May	6.6	0.00	0.00	0.00	—	0.00	0.00	0.00	—	4.8	0.00	0.00	0.75	0.00	0.02	0.00	0.00	0.41	—
	June	205.0	0.00	0.00	0.00	—	0.00	0.00	0.00	—	1170.0	0.00	0.00	0.55	0.27	0.27	0.00	0.00	0.10	—
	July	345.6	0.00	0.41	1.24	—	0.00	0.00	0.43	—	1181.7	0.09	0.09	0.86	0.01	0.08	0.00	0.09	3.0	—
	August	888.9	0.10	3.4	6.5	—	0.00	1.0	3.4	—	60.6	0.00	0.45	1.7	0.34	0.34	0.00	0.55	11.7	—
	September	1677.8	0.00	1.6	2.7	—	0.11	0.00	2.9	—	127.8	0.11	4.5	6.0	0.19	0.44	0.11	0.79	6.7	—
	October	1410.0	0.68	1.8	2.3	—	0.00	1.00	0.41	—	399.0	0.00	1.4	3.8	0.09	0.27	0.00	0.09	3.6	—
	November	393.0	0.00	1.1	0.45	—	0.00	0.11	0.11	—	30.8	0.11	2.7	3.1	0.34	0.38	0.00	0.11	0.39	—
	December	87.7	0.00	0.10	0.70	—	0.00	0.00	0.00	—	47.9	0.00	0.10	0.00	0.07	0.07	0.00	0.00	0.10	—
1941	January	67.6	0.00	0.00	—	0.05	0.00	0.00	—	0.07	18.8	0.00	0.79	—	0.09	—	0.00	0.06	—	0.05
	February	7.7	0.00	0.00	—	0.03	0.00	0.07	—	0.00	4.9	0.00	0.07	—	0.03	—	0.00	0.00	—	0.00
	March	39.8	0.00	0.06	—	0.10	0.73	0.07	—	0.06	44.3	0.17	0.73	—	0.05	—	0.07	0.79	—	0.09
	April	77.7	0.00	0.07	—	0.09	0.00	0.00	—	0.07	3.7	0.00	0.17	—	0.07	—	0.00	0.00	—	0.01
	May	75.9	0.00	0.00	—	0.04	0.00	0.00	—	0.01	116.0	0.00	0.17	—	0.05	—	0.00	0.00	—	0.03
	June	84.0	0.70	0.60	—	0.36	0.00	0.54		0.33	1356.0	0.73	0.70	—	0.79	—	0.00	1.9	—	0.45
	July	1175.7	0.00	0.55	—	0.11	0.00	1.07	—	0.05	1079.6	0.00	0.00	—	0.11	—	0.00	0.74	—	0.08
	August	751.0	0.00	0.74	—	0.31	0.00	0.16	—	0.00	453.0	0.00	0.13	—	0.14	—	0.00	0.16	—	0.04
	September	563.0	1.3	0.50	—	0.77	—	—	—	—	385.0	0.00	0.46	—	0.23	—	0.00	0.00	—	0.04
	October	1190.0	0.00	0.67	—	0.24	—	—	—	—	614.0	0.00	0.40	—	0.35	—	0.00	0.55	—	0.17
	November	376.0	0.71	0.79	—	0.03	0.79	0.71	—	0.70	146.7	0.00	1.5	—	0.30	—	0.07	0.07	—	0.17
	December	140.7	0.00	0.06	—	0.16	0.00	0.00	—	0.09	19.8	0.06	0.36	—	0.37	—	1.7	0.07	—	0.18

See adjoining page for remarks.

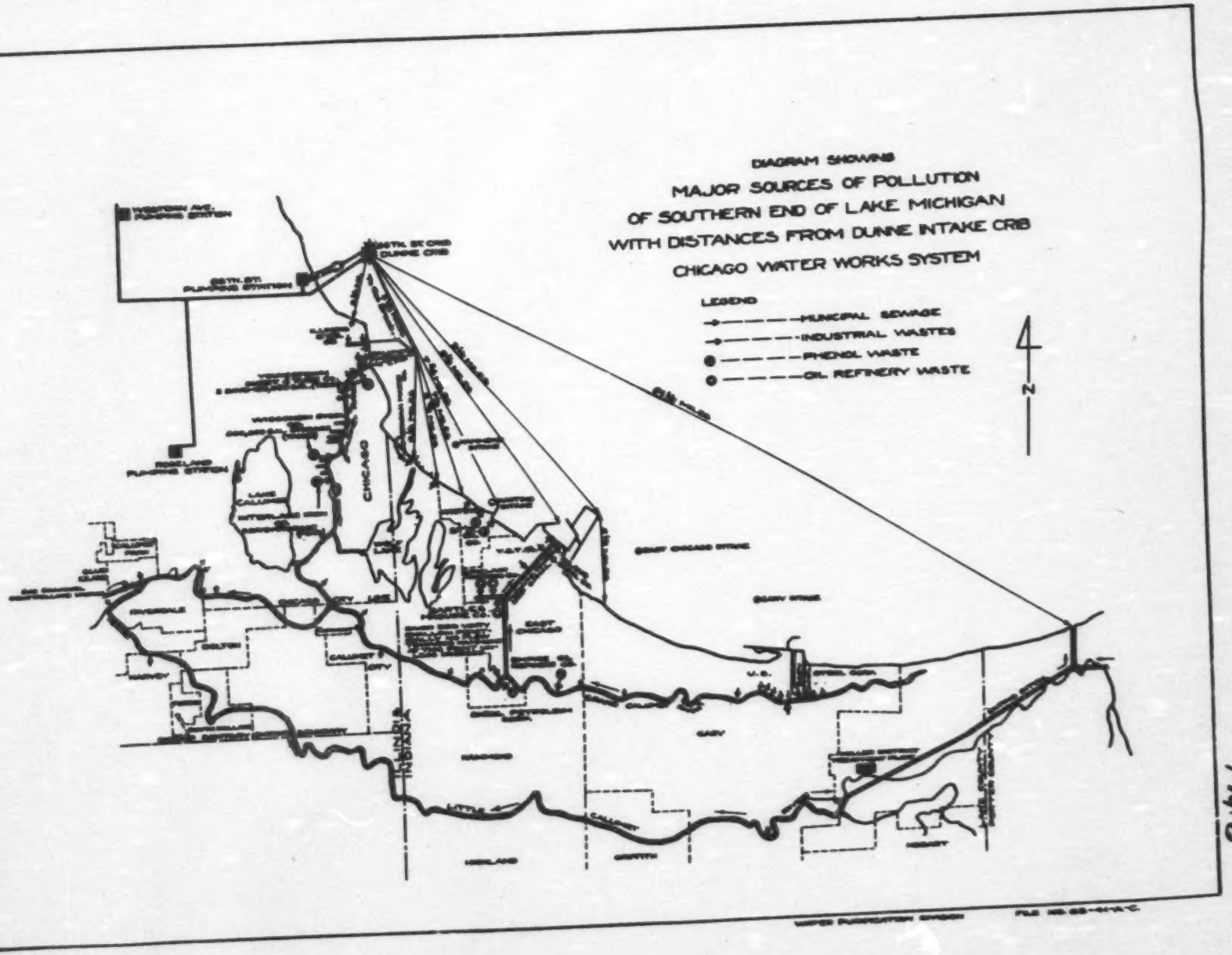
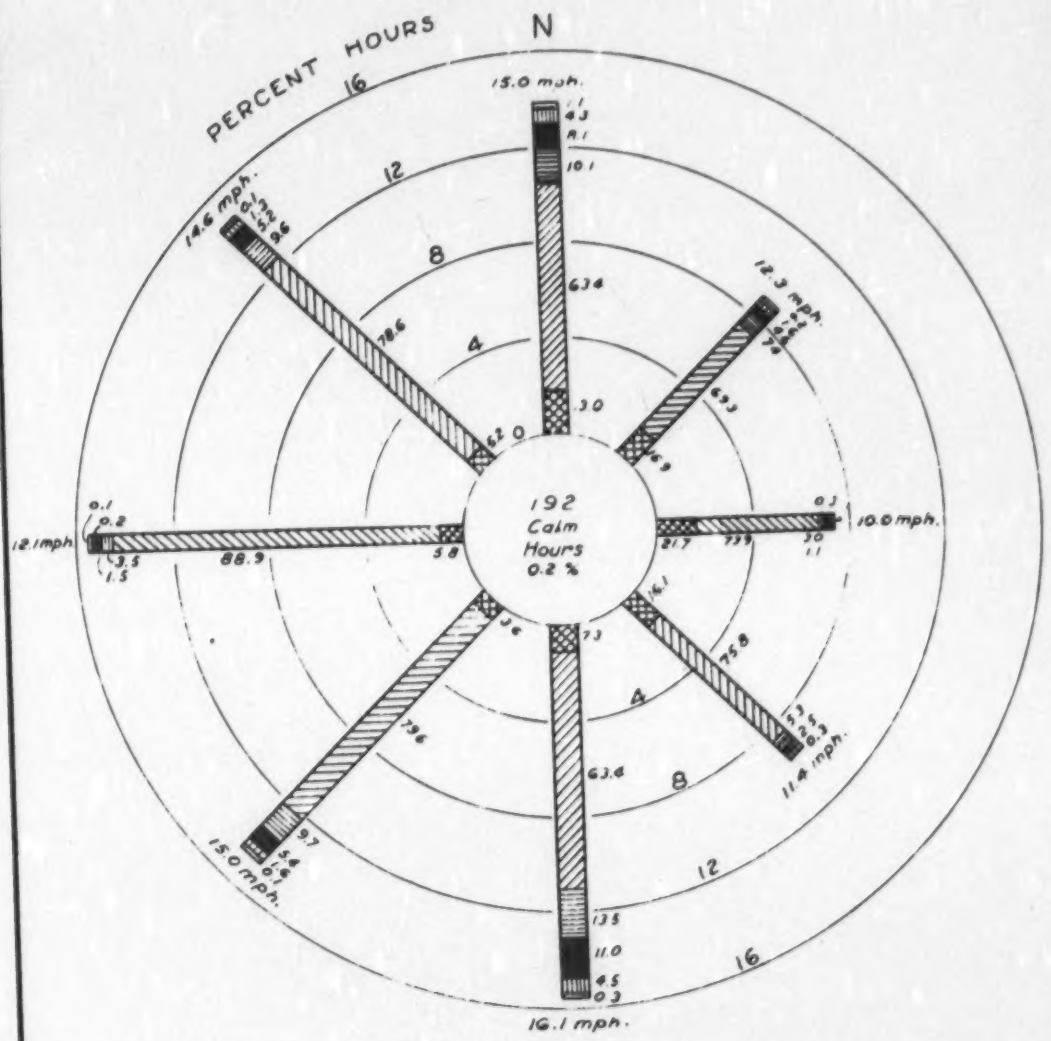


DIAGRAM SHOWING
MAJOR SOURCES OF POLLUTION
OF SOUTHERN END OF LAKE MICHIGAN
WITH DISTANCES FROM DUNNE INTAKE CRIB
CHICAGO WATER WORKS SYSTEM
LEGEND
MUNICIPAL SEWAGE
INDUSTRIAL WASTES
PHENOL WASTE
OIL REFINERY WASTE
N
CHICAGO
GARY
HAMMOND

Fig. 6

FIG. 7

NAVY PIER WIND ROSE
1927 – 1936



Average Velocity - 13.7 mph.
Prevailing Direction - SOUTH

LEGEND

1-5 6-20 21-24 25-30 31-40 OVER 40
HOURLY VELOCITY RANGE
IN PERCENT
EACH DIRECTION = 100 %

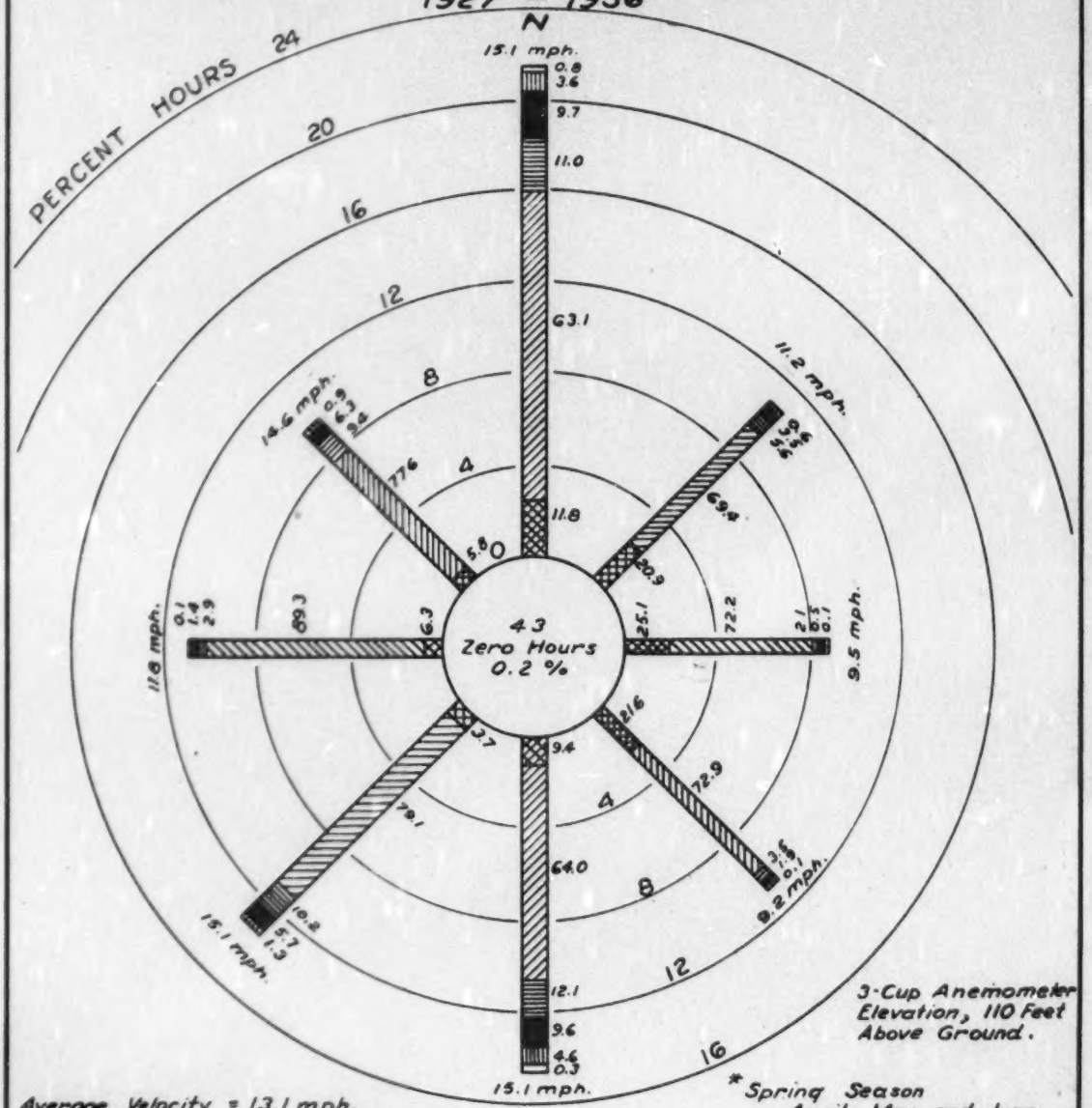
CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
WATER PURIFICATION DIVISION

Sheet 13 of 15

FILE NO. 6.3-24 A

NAVY PIER WIND ROSE
AVERAGE SPRING * SEASON
1927 – 1936

Fig 6



3-Cup Anemometer
Elevation, 110 Feet
Above Ground.

* Spring Season
April, May and June.
April 1, 1927 to June 30, 1936

Average Velocity = 13.1 mph.
Prevailing Direction = NORTH

LEGEND

1-5 6-20 21-24 25-30 31-40 OVER 40

HOURLY VELOCITY RANGE
IN PERCENT
EACH DIRECTION = 100 %

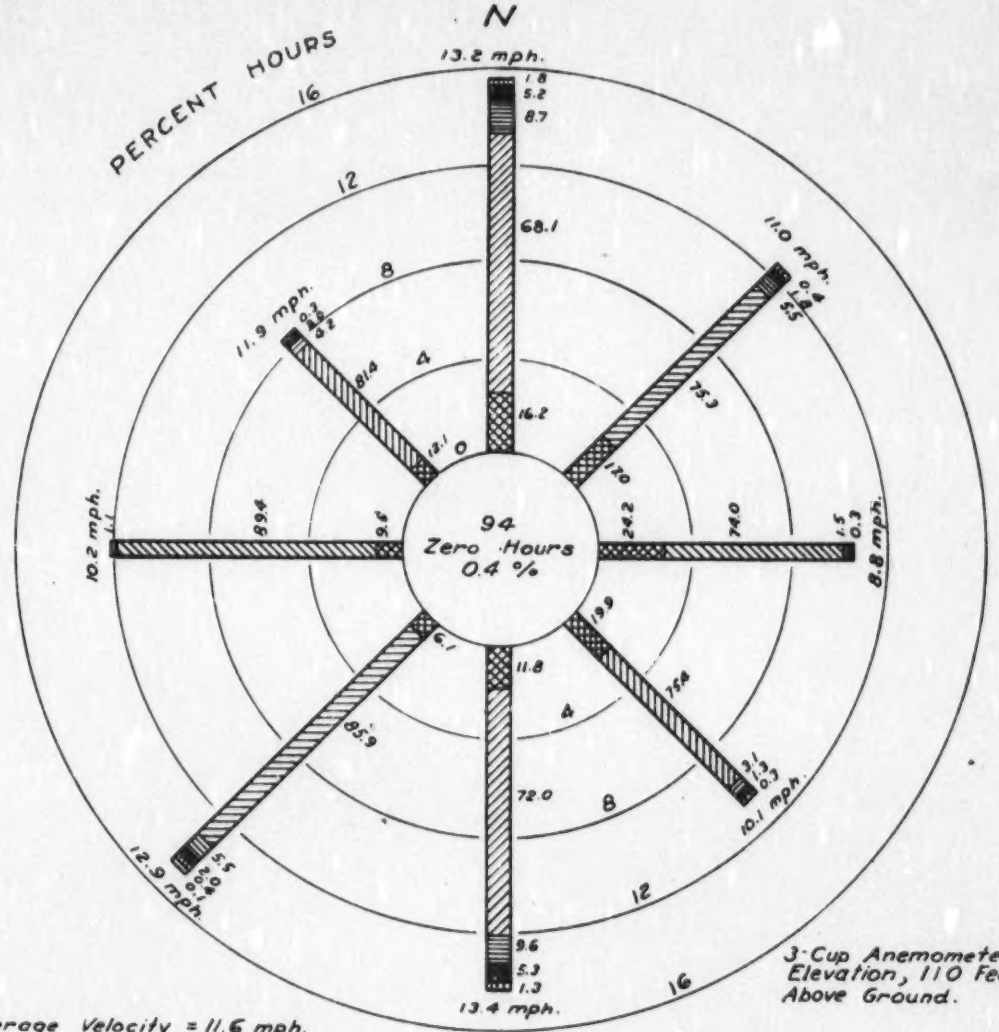
CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

WATER PURIFICATION DIVISION

Sheet 2 of 4
FILE NO. 6.3-28 A

FIG 9

NAVY PIER WIND ROSE
AVERAGE SUMMER* SEASON
1927 - 1936



3-Cup Anemometer
Elevation, 110 Feet
Above Ground.

Average Velocity = 11.6 mph.
Prevailing Direction = NORTH.

*Summer Season
July, August and September.
July 1, 1927 to September 30, 1936

LEGEND

1-5 6-20 21-24 25-30 31-40 OVER 40

HOURLY VELOCITY RANGE
IN PERCENT
EACH DIRECTION = 100 %

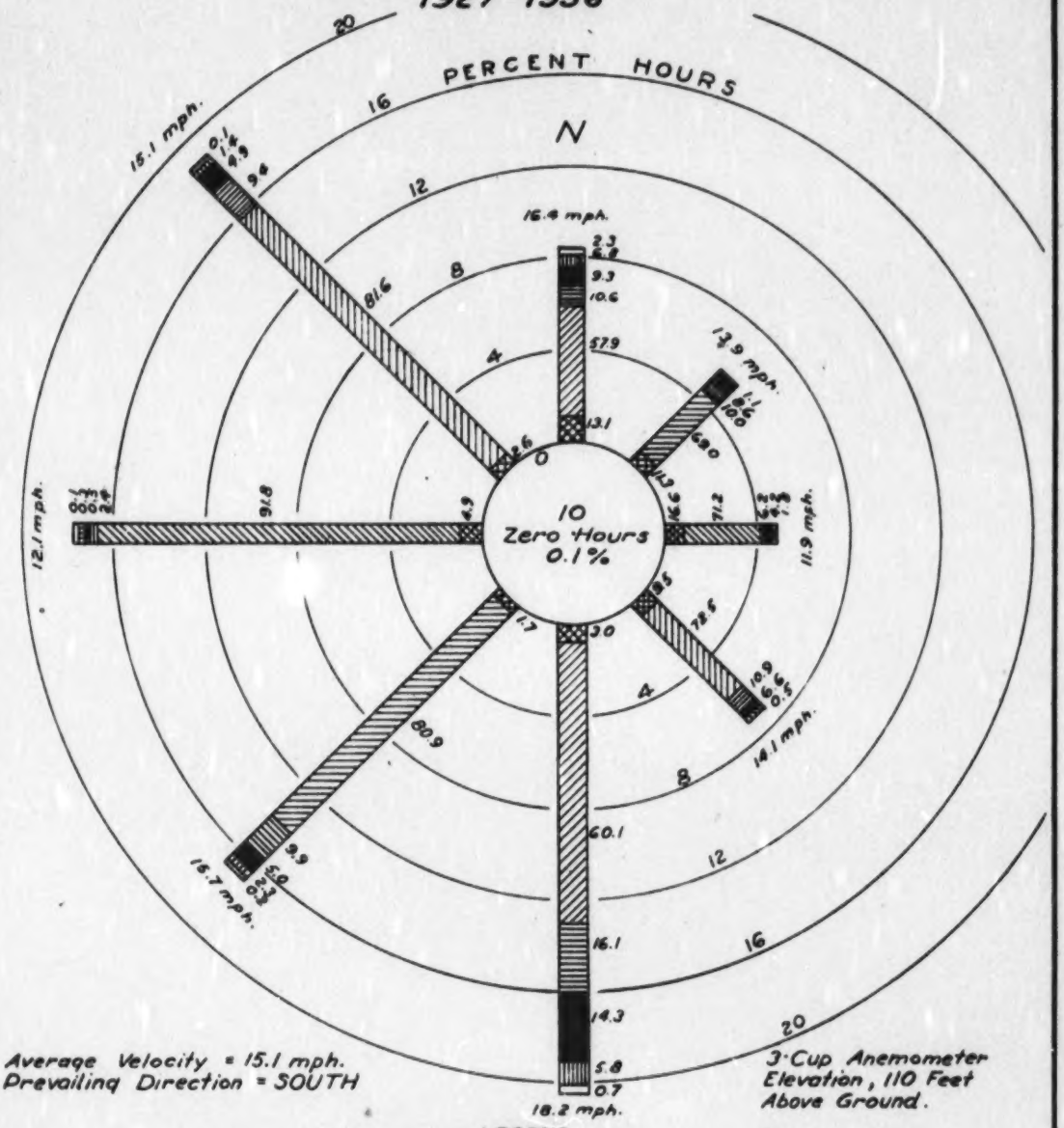
CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

WATER PURIFICATION DIVISION

Sheet 3 of 4
FILE NO. 6.3-28A

FIG. 10

NAVY PIER WIND ROSE
AVERAGE FALL* SEASON
1927-1936



Average Velocity = 15.1 mph.
Prevailing Direction = SOUTH

3-Cup Anemometer
Elevation, 110 Feet
Above Ground.

* Fall Season,
October and
November
October 1, 1937 to
November 30, 1936

LEGEND

1-5 6-20 21-29 25-30 31-40 OVER 40

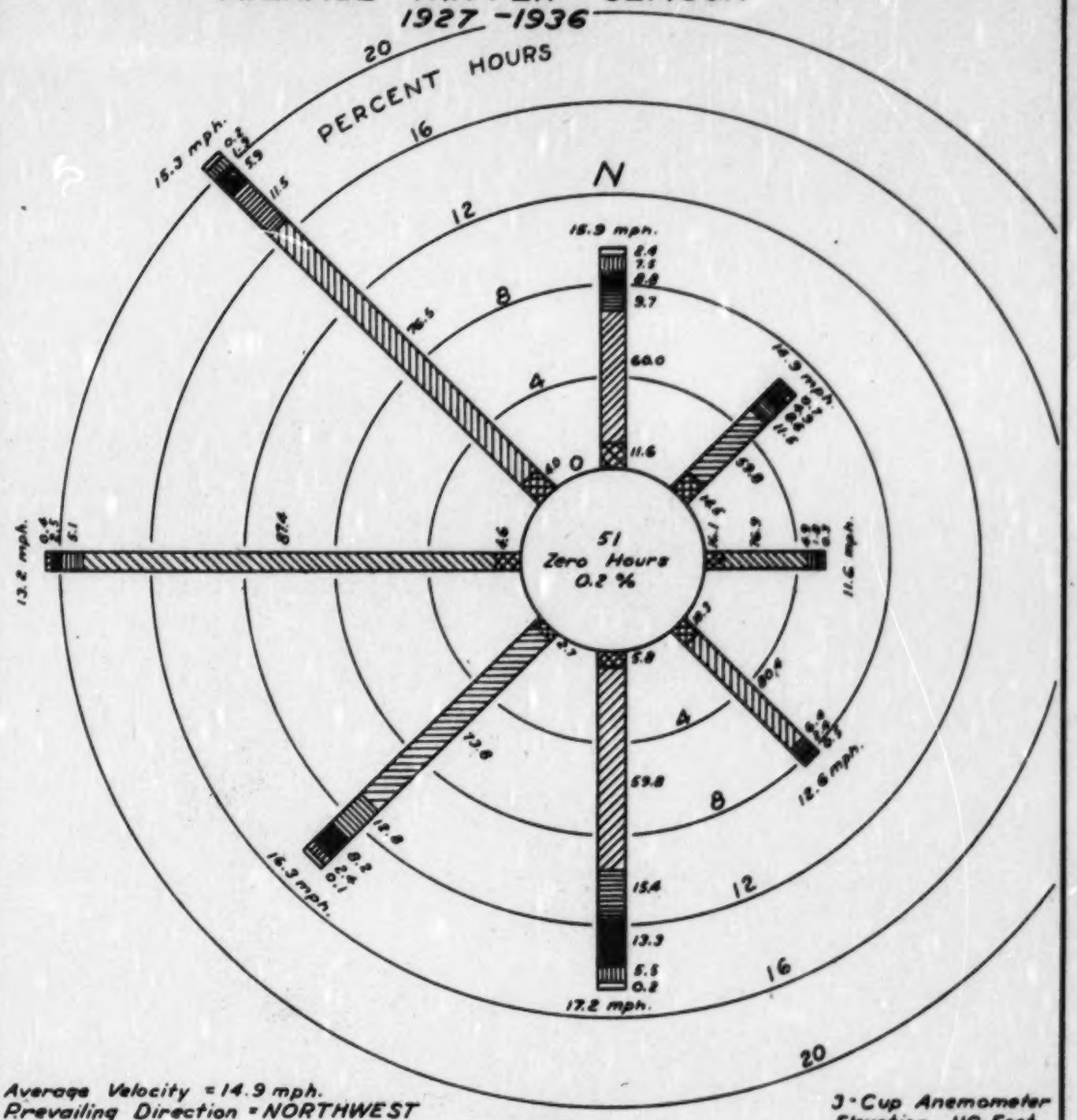
HOURLY VELOCITY RANGE
IN PERCENT
EACH DIRECTION = 100 %

CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
WATER PURIFICATION DIVISION

Sheet 4 of 4
FILE NO. 6.3-28A

FIG. 11

NAVY PIER WIND ROSE
AVERAGE WINTER * SEASON
1927 - 1936



Average Velocity = 14.9 mph.
Prevailing Direction = NORTHWEST

3-Cup Anemometer
Elevation, 110 Feet
Above Ground.

LEGEND

1-5 6-20 21-24 25-30 31-40 OVER 40
HOURLY VELOCITY RANGE
IN PERCENT
EACH DIRECTION = 100 %

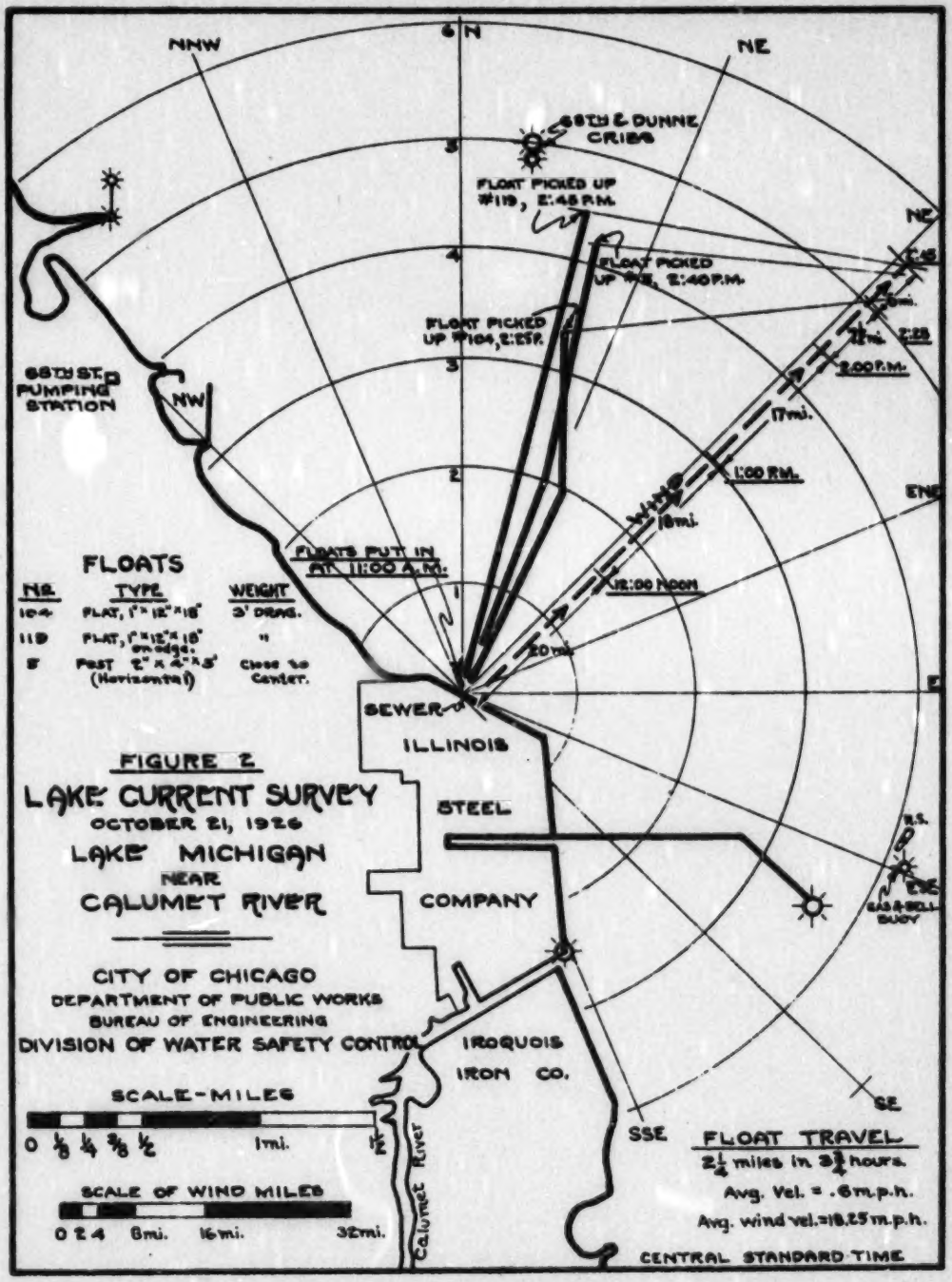
* Winter Season
December, January,
February and March.
December 1, 1926 To
March 31, 1936

CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

WATER PURIFICATION DIVISION

Sheet 1 of 4
FILE NO. 6.3-28A

FIG 12


NNW
N
NE
68TH & DUNNE CRIBS
FLOAT PICKED UP #119, 2:45 P.M.
FLOAT PICKED UP #118, 2:40 P.M.
FLOAT PICKED UP #104, 2:25 P.M.
68TH ST. PUMPING STATION
NW
NE
2:45
2:25
2:00 P.M.
17mi.
1:00 P.M.
18mi.
ENE
FLOATS PUT IN AT 11:00 A.M.
12:00 NOON
20 mi.
E
SEWER
ILLINOIS STEEL COMPANY
U.S. ENG. BAR & BELL BUOY
IROQUOIS IRON CO.
SE
SSE
Calumet River
FLOATS
NO. TYPE WEIGHT
104 FLAT, 1" x 12" x 18" 3' DRAG.
119 FLAT, 1" x 12" x 18" on edge. "
5 POST 2" x 4" x 5' (Horizontal) Close to Center.
FIGURE 2
LAKE CURRENT SURVEY
OCTOBER 21, 1926
LAKE MICHIGAN
NEAR
CALUMET RIVER
CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
DIVISION OF WATER SAFETY CONTROL
SCALE-MILES
0 1/8 1/4 3/8 1/2 1mi.
SCALE OF WIND MILES
0 2 4 8mi. 16mi. 32mi.
FLOAT TRAVEL
2 1/4 miles in 3 3/4 hours.
Avg. Vel. = .6 m.p.h.
Avg. wind vel. = 18.25 m.p.h.
CENTRAL STANDARD TIME

J-3-3

FIG. 13

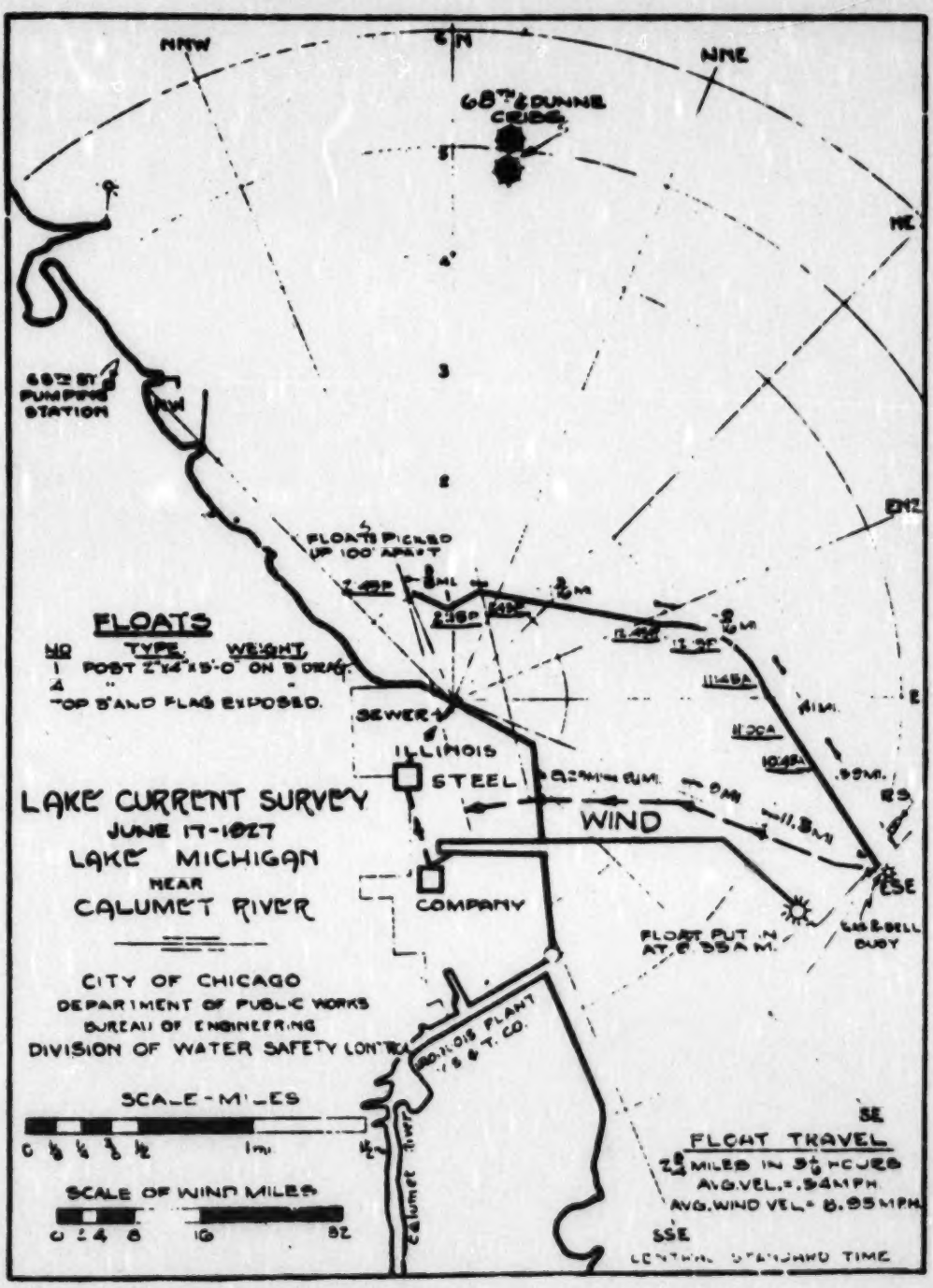


FIGURE No. 9

J-3

FIG. 14

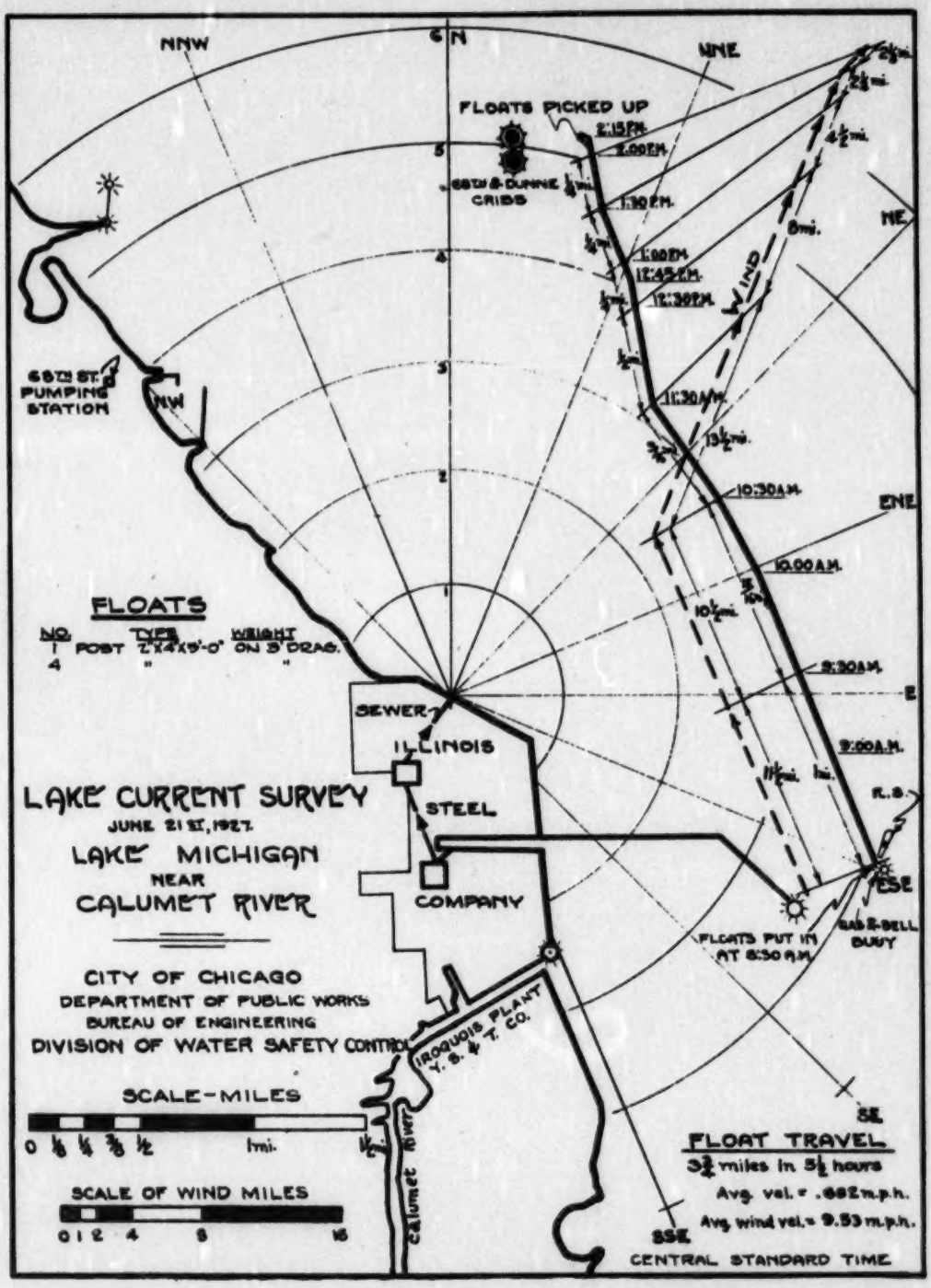


FIGURE No. 10

J-3-2-A

FIG. 15

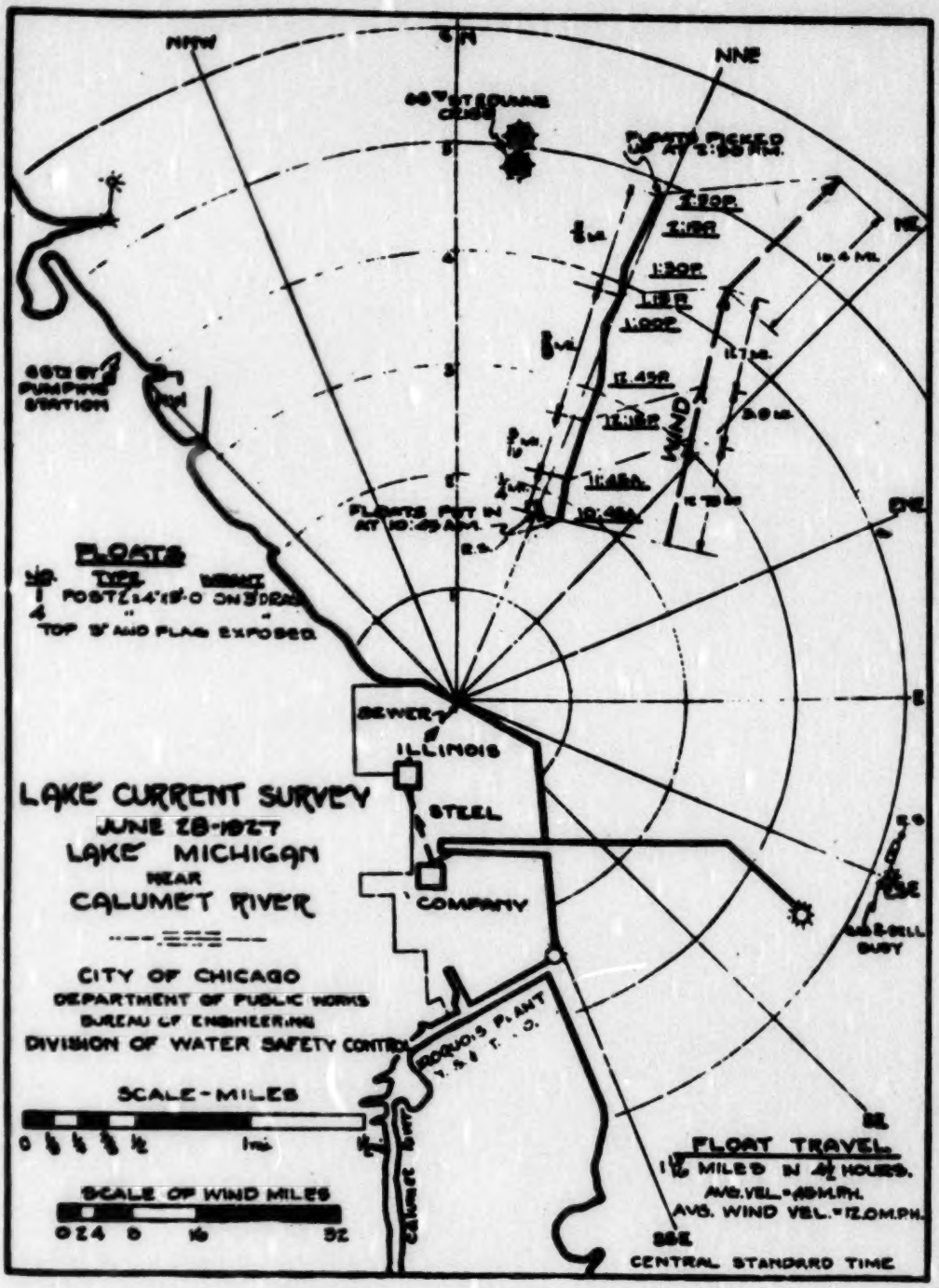


FIGURE No. 11

FIG. 16

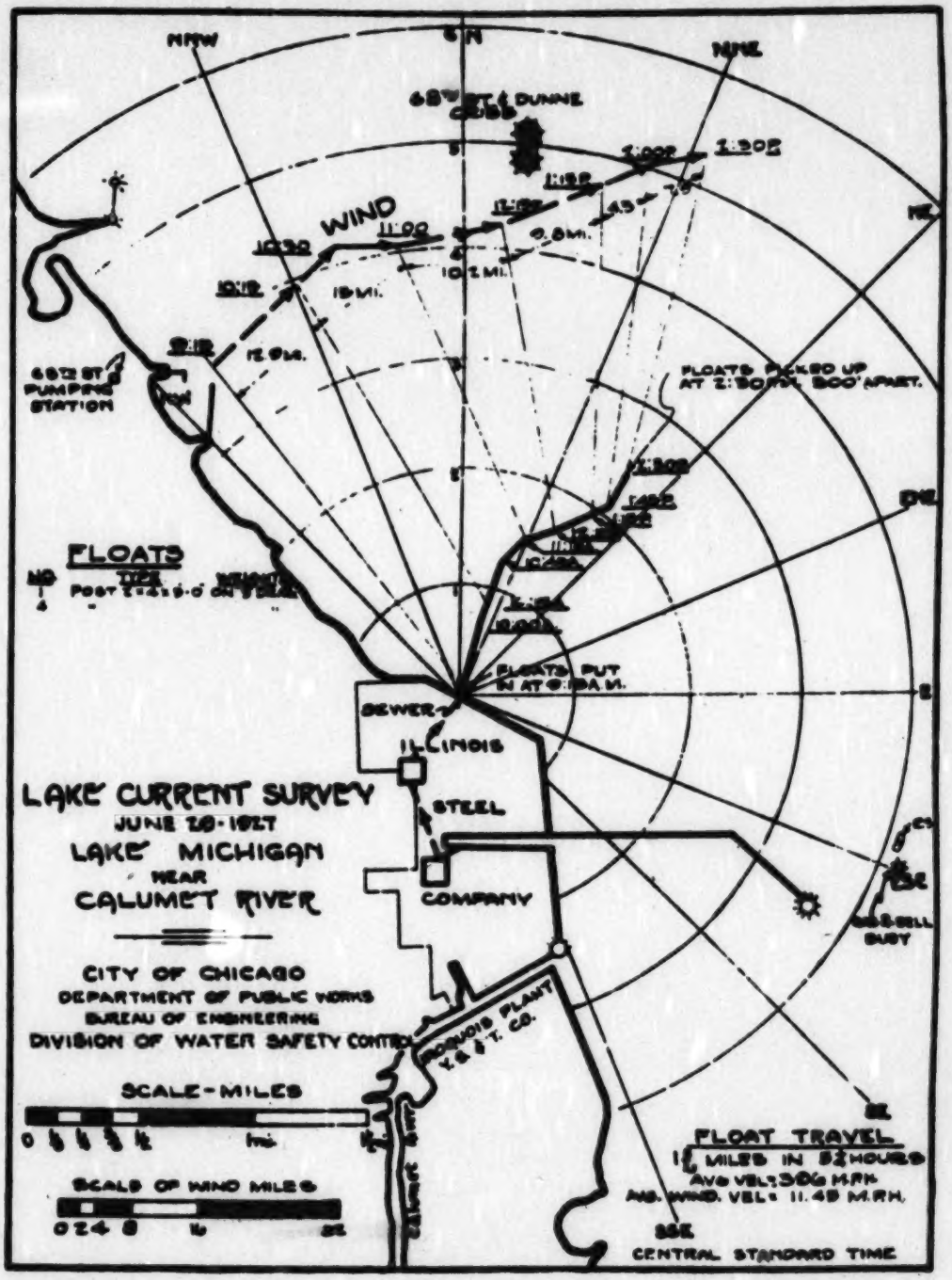
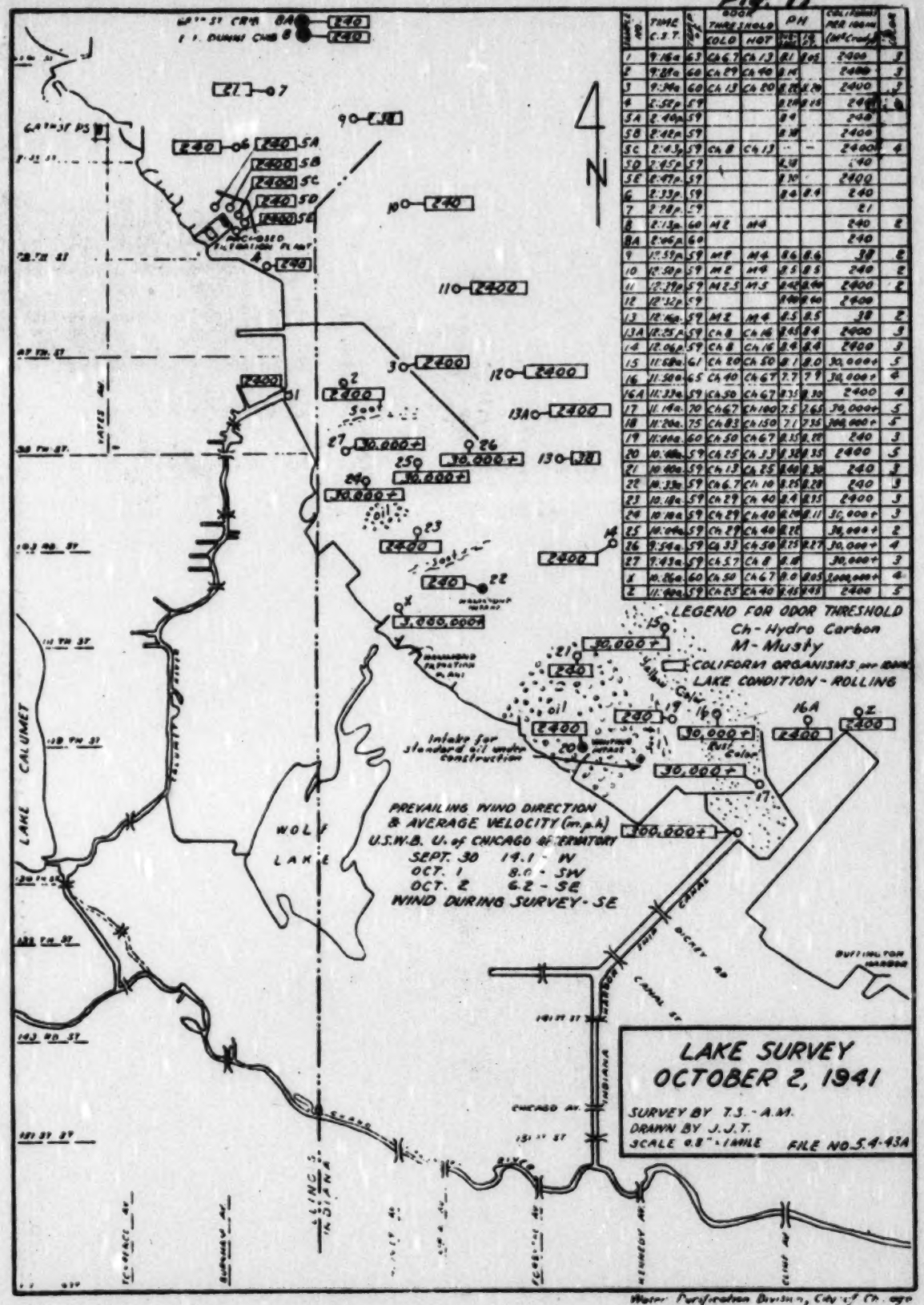
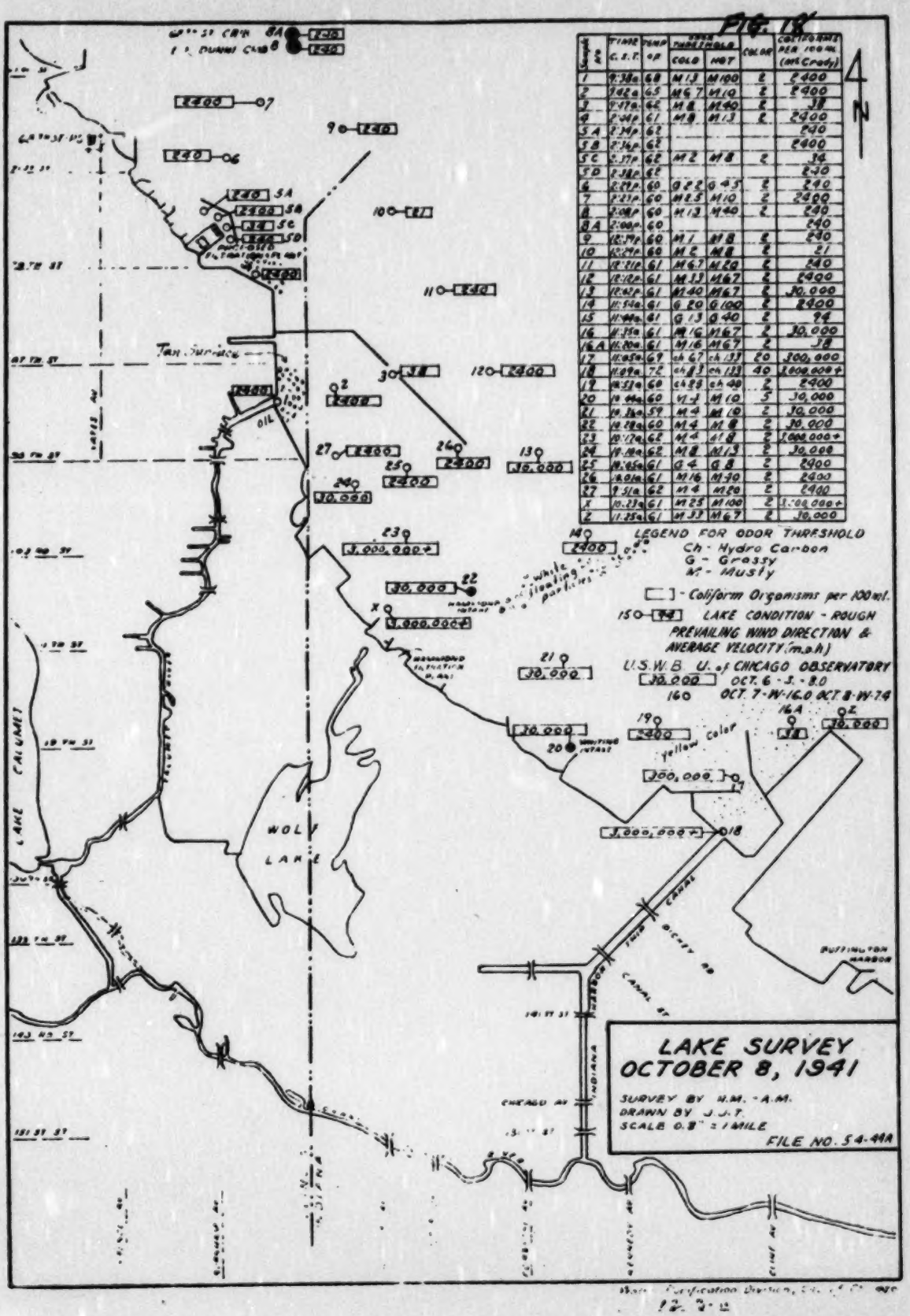


FIGURE No. 12

Fig. 17


LAKE CALUMET
WOLF LAKE
LEGEND FOR ODOR THRESHOLD
Ch - Hydro Carbon
M - Musty
COLIFORM ORGANISMS per 100 ml
LAKE CONDITION - ROLLING
Intake for Standard Oil under construction
PREVAILING WIND DIRECTION & AVERAGE VELOCITY (m.p.h.)
U.S.W.B. U. of CHICAGO OBSERVATORY
SEPT. 30 19.1 - W
OCT. 1 8.0 - SW
OCT. 2 6.2 - SE
WIND DURING SURVEY - SE
LAKE SURVEY
OCTOBER 2, 1941
SURVEY BY T.S. - A.M.
DRAWN BY J.J.T.
SCALE 0.8" = 1 MILE
FILE NO. S-4-43A
Water Purification Division, City of Chicago
12 D-11

STATION NO.	TIME C.S.T.	AIR TEMP.	ODOR THRESHOLD COLD	ODOR THRESHOLD HOT	pH		COLIFORMS PER 100 ml (Incl. Crowded)	
1	9:16a	63	Ch 6.7	Ch 13	8.1	7.95	2400	3
2	9:28a	60	Ch 29	Ch 90	8.1		2400	3
3	9:36a	60	Ch 13	Ch 20	8.15	8.10	2400	3
4	2:55p	59			8.10	8.15	240	4
5A	2:40p	59			8.1		240	
5B	2:42p	59			8.10		2400	
5C	2:43p	59	Ch 8	Ch 13	-	-	2400	4
5D	2:45p	59			8.10		240	
5E	2:47p	59			8.10		2400	
6	2:33p	59			8.4	8.4	240	
7	2:28p	59					21	
8	2:13p	60	M2	M4			240	2
8A	2:06p	60					240	
9	1:59p	59	M2	M4	8.6	8.6	38	2
10	1:50p	59	M2	M4	8.5	8.5	240	2
11	1:39p	59	M2.5	M5	8.45	8.40	2400	2
12	12:52p	59			8.40	8.40	2400	
13	12:46p	59	M2	M4	8.5	8.5	38	2
13A	12:25p	59	Ch 8	Ch 16	8.45	8.4	2400	3
14	12:06p	59	Ch 8	Ch 16	8.4	8.4	2400	3
15	11:58a	61	Ch 80	Ch 50	8.1	8.0	30,000+	5
16	11:50a	65	Ch 40	Ch 67	7.7	7.9	30,000+	4
16A	11:33a	59	Ch 50	Ch 67	8.35	8.30	2400	4
17	11:14a	70	Ch 67	Ch 100	7.5	7.65	30,000+	5
18	11:00a	75	Ch 83	Ch 150	7.1	7.35	300,000+	5
19	11:00a	60	Ch 50	Ch 67	8.15	8.15	240	3
20	10:48a	59	Ch 25	Ch 33	8.35	8.35	2400	5
21	10:40a	59	Ch 13	Ch 25	8.40	8.30	240	3
22	10:32a	59	Ch 6.7	Ch 10	8.25	8.28	240	3
23	10:18a	59	Ch 29	Ch 40	8.4	8.35	2400	3
24	10:08a	59	Ch 29	Ch 40	8.20	8.11	30,000+	3
25	10:00a	59	Ch 29	Ch 40	8.20		30,000+	2
26	9:54a	59	Ch 33	Ch 50	8.25	8.27	30,000+	4
27	9:43a	59	Ch 5.7	Ch 8	8.10		30,000+	3
X	10:56a	60	Ch 50	Ch 67	8.0	8.05	300,000+	4
Z	11:09a	59	Ch 25	Ch 40	8.45	8.43	2400	5


LAKE SURVEY
OCTOBER 8, 1941
SURVEY BY H.M. - A.M.
DRAWN BY J.J.T.
SCALE 0.8" = 1 MILE
FILE NO. 54-44A
LEGEND FOR ODOR THRESHOLD
Ch - Hydro Carbon
G - Grassy
M - Musty
[ ] - Coliform Organisms per 100 ml.
LAKE CONDITION - ROUGH
PREVAILING WIND DIRECTION & AVERAGE VELOCITY (m.p.h.)
U.S.W.B. U. of CHICAGO OBSERVATORY
OCT. 6 - S - 8.0
OCT. 7 - W - 16.0 OCT. 8 - W - 7.4
LAKE CALUMET
WOLF LAKE
INDIANA HARBOR CANAL
BURNHAM HARBOR
yellow color
white floating particles
Gary Sanitation District

Sample No.	Time C.S.T.	Temp °F	Odor Threshold Cold	Odor Threshold Hot	Color	Coliforms per 100 ml. (MF Cndy)
1	9:30a	68	M13	M100	2	2400
2	9:42a	65	M67	M10	2	2400
3	9:47a	64	M8	M40	2	38
4	9:49a	61	M8	M13	2	2400
5A	9:34a	62				240
5B	9:36a	62				2400
5C	9:37a	62	M2	M8	2	14
5D	9:38a	61				240
6	9:27a	60	G22	G45	2	240
7	9:21a	60	M25	M10	2	2400
8	9:08a	60	M13	M40	2	240
8A	9:00a	60				240
9	10:19a	60	M7	M18	2	240
10	10:24a	60	M2	M8	2	21
11	10:31a	61	M67	M20	2	240
12	10:32a	61	M13	M67	2	2400
13	10:42a	61	M40	M67	2	30,000
14	11:54a	61	G20	G100	2	2400
15	11:44a	61	G13	G40	2	94
16	11:39a	61	M16	M67	2	30,000
16A	11:20a	61	M16	M67	2	38
17	11:05a	69	ch67	ch33	20	300,000
18	11:09a	72	ch3	ch133	40	1,000,000+
19	10:53a	60	ch88	ch40	2	2400
20	10:44a	60	M3	M10	5	30,000
21	10:34a	59	M4	M10	2	30,000
22	10:28a	60	M4	M8	2	30,000
23	10:17a	62	M4	M8	2	1,000,000+
24	10:10a	62	M8	M13	2	30,000
25	10:05a	61	G4	G8	2	2400
26	9:01a	61	M16	M40	2	2400
27	9:51a	62	M4	M20	2	2400
X	10:23a	61	M25	M100	2	1,000,000+
Z	11:25a	61	M33	M67	2	30,000

12-3-41

FIG 19

CITY OF CHICAGO
BUREAU OF ENGINEERING
DEPARTMENT OF PUBLIC WORKS
WATER PURIFICATION DIVISION

SUMMARY OF CALUMET RIVER FLOW
1941

MONTH	HOURS			HIGHEST AVERAGE OUT FOR ANY HOUR FEET PER SEC.	LONGEST CONTINUOUS OUT PERIOD.			
					.6 FEET PER SECOND OR MORE		.3 FEET PER SECOND OR MORE	
	OUT	IN	NO FLOW		HOURS	DATE OF START	HOURS	DATE OF START
JANUARY	484	18	242	1.1	21	1-19	12	1-9
FEBRUARY	461	—	211	1.6	18	2-19	9	2-19
MARCH	402	13	329	1.2	22	3-4 3-5	8	3-4 3-13 3-29
APRIL *	376	73	270	1.1	7	4-13	16	4-20
MAY	223	206	315	1.3	5	5-17	5	5-10 5-22 5-27
JUNE	185	224	311	1.2	5	6-13	7	6-4
JULY	122	321	301	1.3	4	7-3	4	7-27
AUGUST	105	384	255	.5	6	8-11	4	8-19
SEPTEMBER	212	369	139	1.0	10	9-27	8	9-27
OCTOBER Ø	399	163	183	1.6	10	10-31	16	10-7
NOVEMBER	342	119	259	1.0	14	11-25	22	11-2
DECEMBER	281	167	296	1.0	11	12-20	15	12-12
YEAR TOTAL	3592	2057	3111	13.9	133	—	126	—
YEAR AVERAGE	299	171	259	1.16	1.10	—	10.5	—

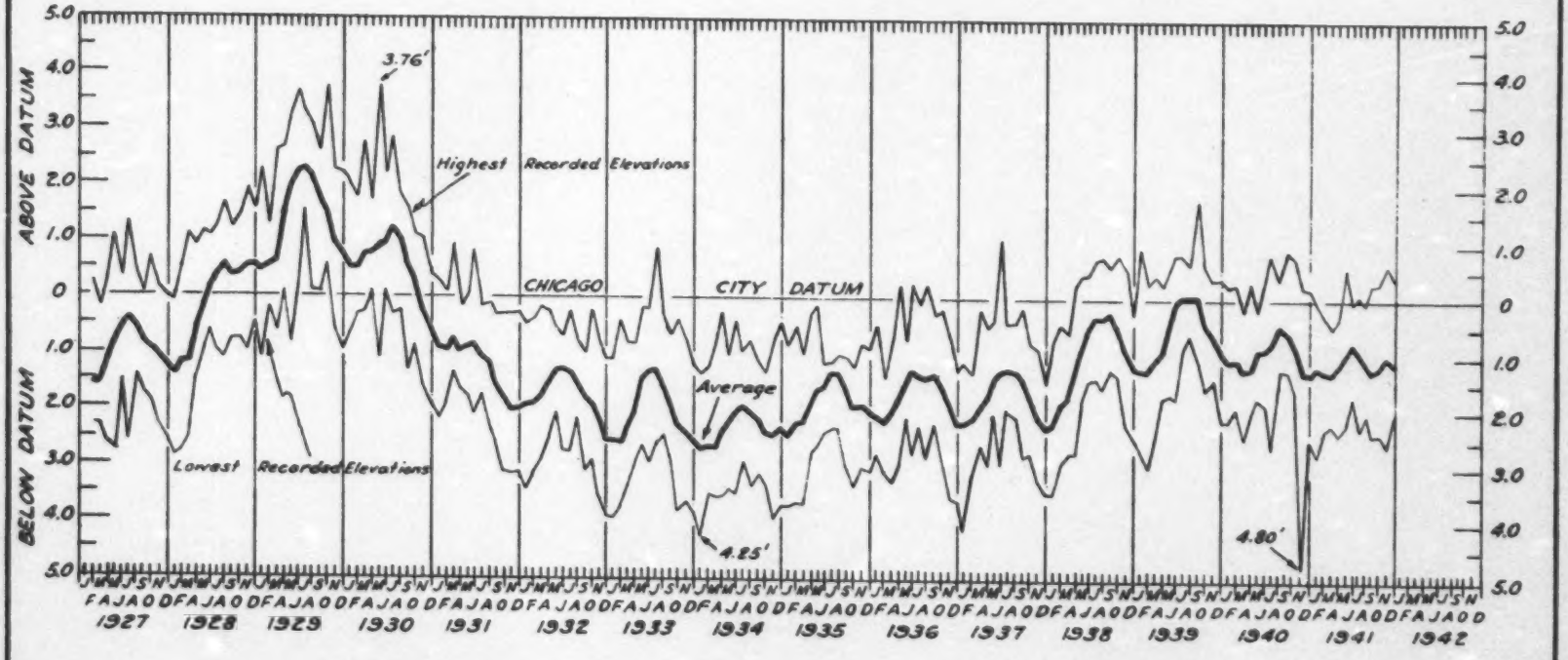
* One hour short % Daylight Savings Time change.
Ø One hour over % change back to Standard Time.

JT

LAKE MICHIGAN FLUCTUATIONS

RECORDED AT NAVY PIER

1927-1942



NOTE: Chicago City Datum is 579.88 Feet above mean tide level at New York.
Elevations are expressed in feet.

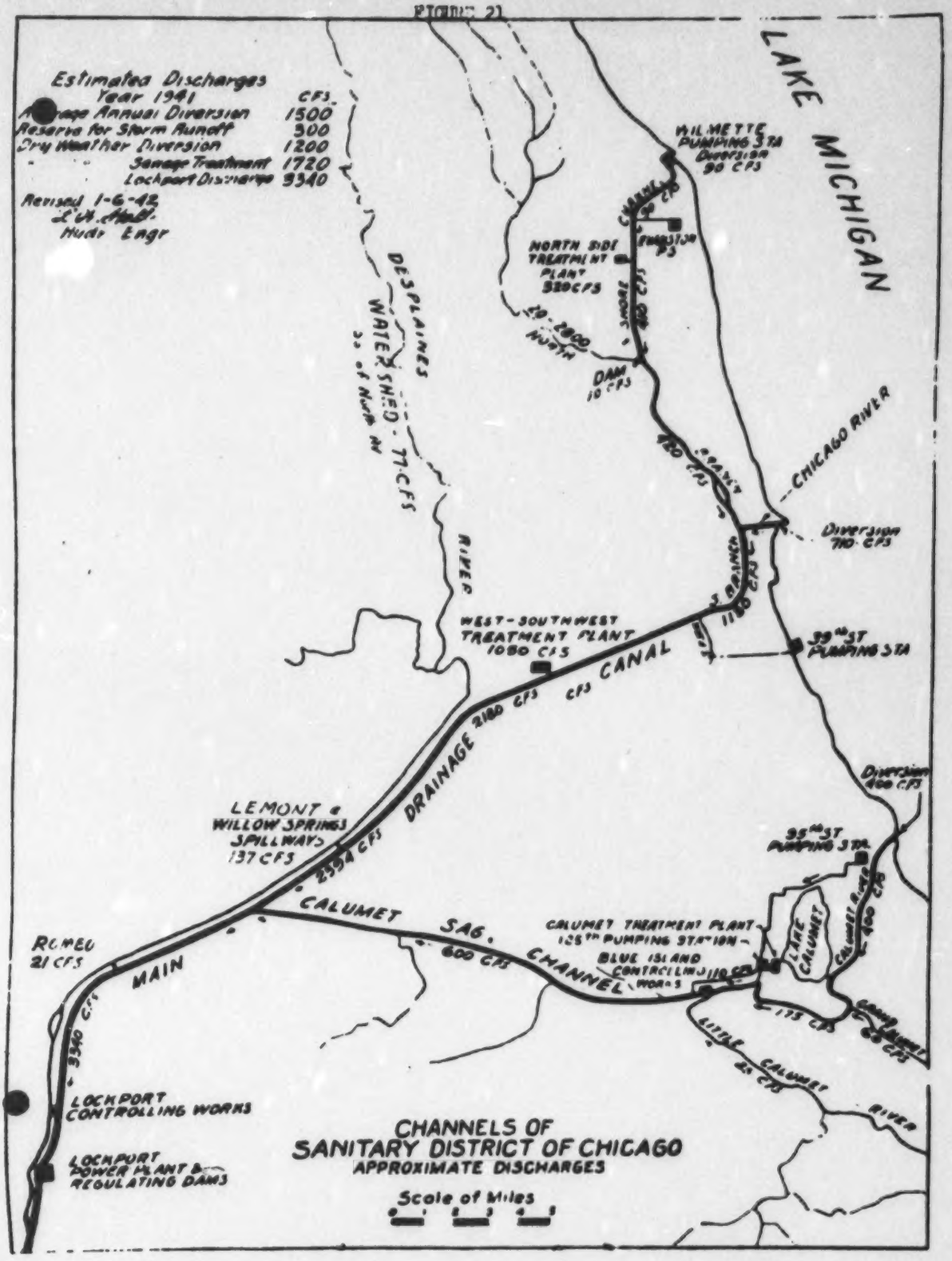
FIG. 20

J.T.

Water Purification Division

FILE NO. 6.4-8A

FIGURE 21


Estimated Discharges
Year 1941
CFS.
Average Annual Diversion 1500
Reserve for Storm Runoff 300
Dry Weather Diversion 1200
Sewage Treatment 1720
Lockport Discharge 3340
Revised 1-6-42
L.H. Hoyt
Hyd. Engr
LAKE MICHIGAN
WILMETTE PUMPING STA
Diversion 90 CFS
NORTH SIDE TREATMENT PLANT 320 CFS
DES PLAINES WATERSHED - 77 CFS
DAM 10 CFS
CHICAGO RIVER
Diversion 710 CFS
WEST-SOUTHWEST TREATMENT PLANT 1080 CFS
39th ST PUMPING STA
CANAL
DRAINAGE 2180 CFS
Diversion 400 CFS
LEMONT & WILLOW SPRINGS SPILLWAYS 137 CFS
2354 CFS
95th ST PUMPING STA
CALUMET
SAG. CHANNEL
600 CFS
CALUMET TREATMENT PLANT
125TH PUMPING STATION
BLUE ISLAND CONTROLLING WORKS
LAKE CALUMET
ROMEO 21 CFS
MAIN
3340 CFS
LOCKPORT CONTROLLING WORKS
LOCKPORT POWER PLANT & REGULATING DAMS
LITTLE CALUMET RIVER
CHANNELS OF
SANITARY DISTRICT OF CHICAGO
APPROXIMATE DISCHARGES
Scale of Miles